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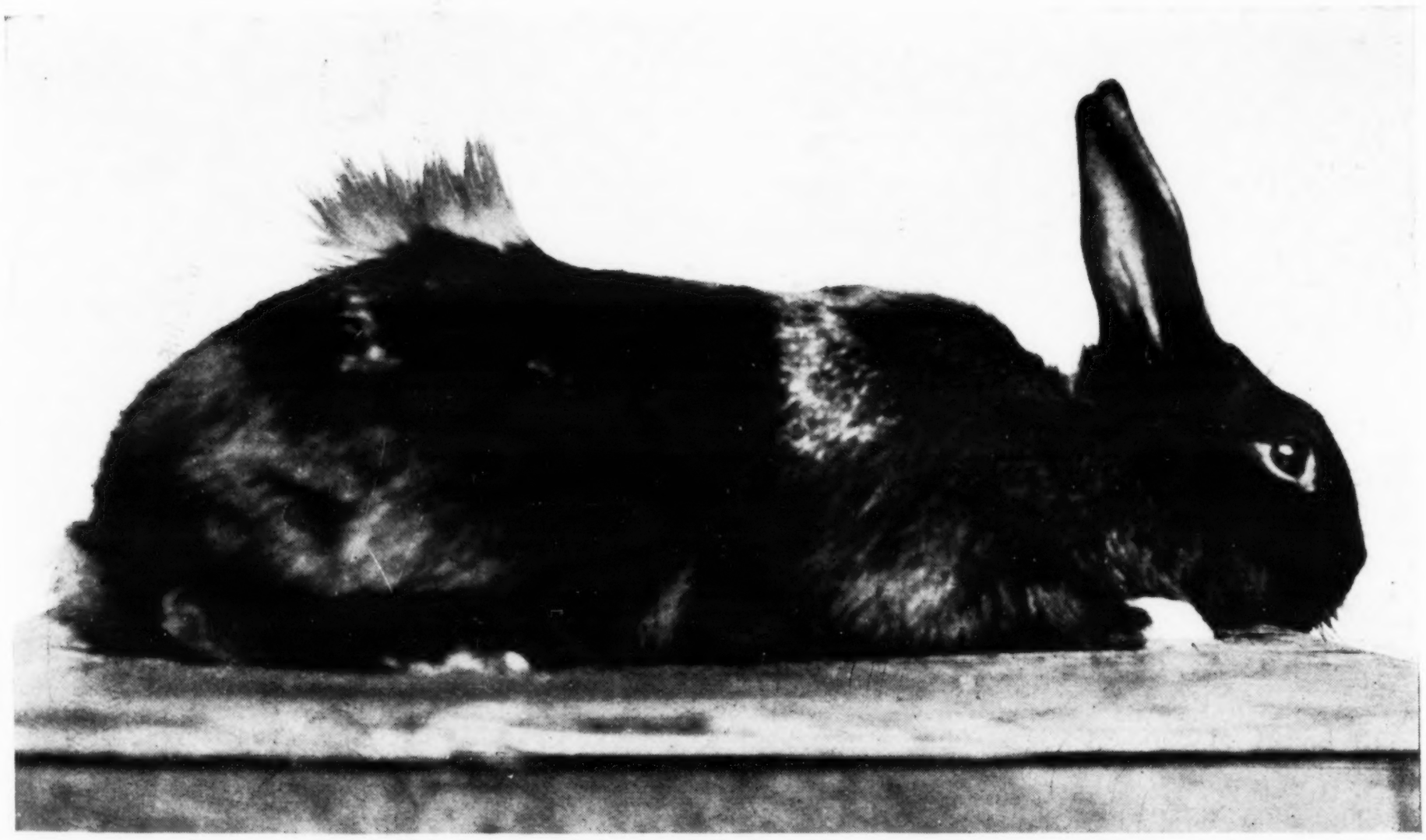

A "SOMATIC SEGREGATED" RABBIT
(SEE PAGE 483)

A Five-Generation Portrait Chart of a Race Cross

Honey-Locust Prizes

The Banda Double Pummelo

Bateson's Scientific Papers

Improved Tree Seed

VOLUME 20 OCTOBER, 1929 NUMBER 10

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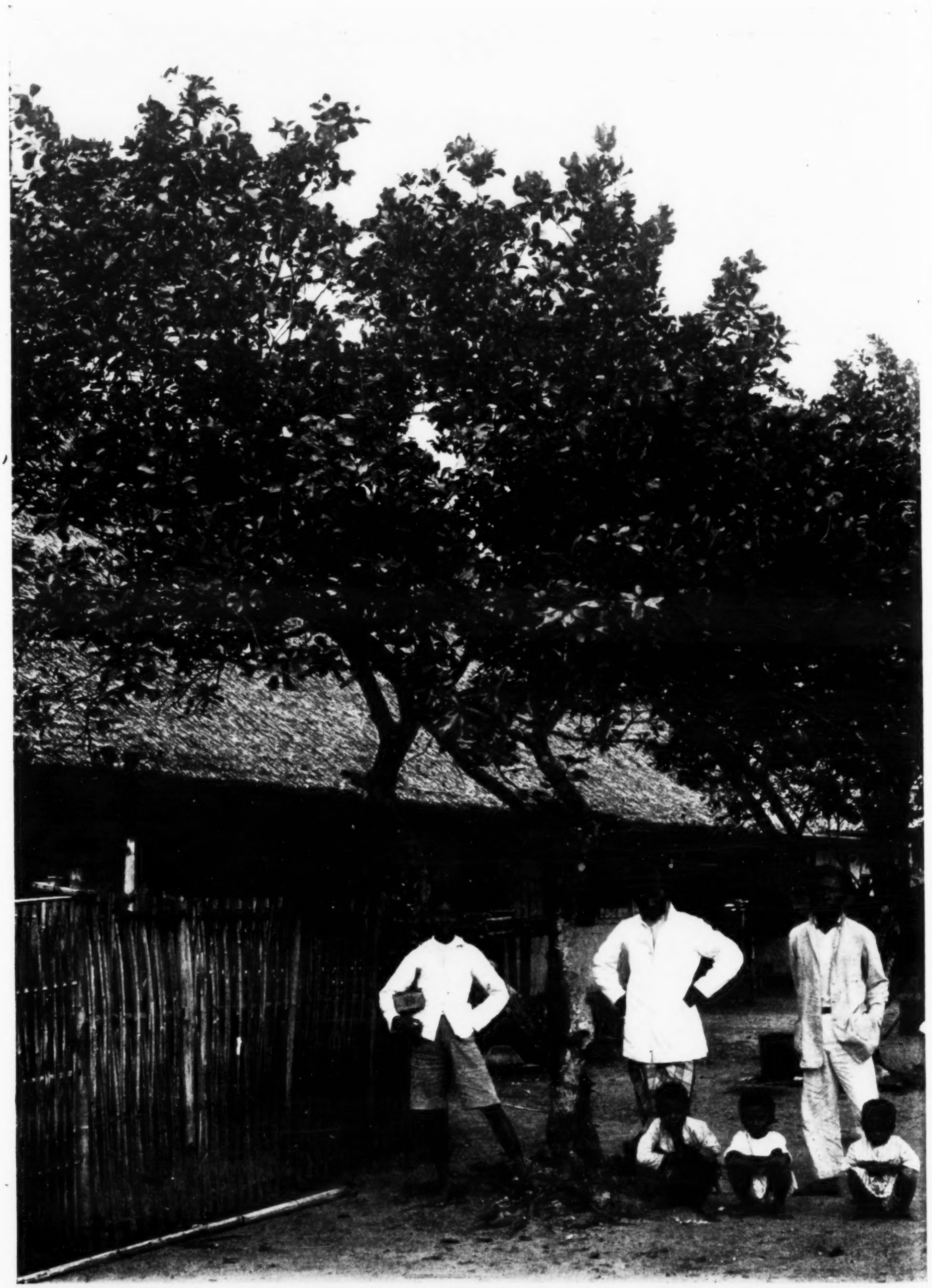


DOUBLE PUMMELO TREES

Frontispiece

The double pummelo was first brought to the attention of the western world two centuries ago by Rumphius. A recent investigation, here reported, shows that the type still exists, though somewhat modified. This view shows the upright type of double pummelo tree—there is also a low, spreading type. Both the upright and the spreading forms appear to be reproduced true to type by air-grafting or "marcottage," the system usually used with this fruit in Ambon. The fruits produced by these trees were white-fleshed, tinged with red. The trees are growing in the gardens of Mr. N. P. Kok, Poeloe Ai, Banda Islands, Dutch East Indies.

THE DOUBLE PUMMELO OF BANDA AND AMBON*

O. A. Reinking

Director of Tropical Research, United Fruit Company, Boston, Massachusetts

DURING the months of July, August and September, 1926, the writer made an investigation of the so-called "Double Pummelo of Banda and Ambon." In 1741, attention was first drawn to this fruit by Rumphius in his work "Herbarium Amboinense."† Rumphius' description of the leaves and fruit, along with the location and history of the plant is as follows:

The fourth variety is the rarest. It has leaves similar to those of the first variety, except that they are very smooth (glaborous) and with non-serrate edges, and rounded at the tip, while some of them have a short point and others are bifid (emarginate). The lower surface is not downy as in the common kind. The fruit is as large as the largest melon, not round but elevated, pear shaped and tuberculed; in clusters of four to five and covered with foveoli. The color resembles that of other kinds. The skin is more than an inch thick, bitter and sulphurous. As for the rest, its scent and flavour are like those of the others. The flesh is white, more juicy and sweeter than the common pummelo and usually without seeds. In this kind it often happens that inside the fruit is formed still another small pummelo or apple the size of a peeled orange, and separated from the surrounding pulp of the big fruit by a thin woolly membrane. Some of them have at the upper top a part of a new rind, otherwise the inside fruit or apple is of the same substance, colour and taste as the pulp of the big. This, however, does not occur in all of the large fruits, but only in a few on the same tree and this phenomenon occurs mostly in fruits from Banda, from where the same was taken to Ambon by seeds where, although they produce large and perfect fruit, the double fruit is seldom seen.

In Batavia, there are pummelos also with a white pulp, but the red ones are preferred. None, however, there produce a double fruit unless they were propagated by seeds from those of Banda, where the finest grow in Plo-ay. In truth, they are most difficult to propagate, as in these, seeds rarely occur.

Name. This species is called *Limo Praegnans* (gravid or swollen). In Malay, *Lemon Bonting,* and also *Lemon Banda.*

The Chinese Atlas, page 131, states that: "The proper native country of these trees and fruits is said to be the twelfth, and principally the southern Chinese province, *Quantong* (Canton), there called "Yeucu"; but by the Portuguese it is called *Jamboa,* which is the same as *Zamboa.*

The fruit of these exceeds in size a man's head. Their pulp is red, juicy and acidulous, resembling half ripe grapes, and if hung in the house, they will keep good for a year. The leaves of young trees, crushed between the hands give a very grateful odour, which almost resembles that of scented nails or hands.

The chief characteristic of the fruit noted during the time of Rumphius was its double nature. The fruit was not round, but elevated, pear shaped and tuberculed. The color of the flesh was white and the fruit was usually without seeds. It was also stated that occasionally the small inner fruit had on the top, in part, a new rind. The double fruit character, presence of a rind on the small inner fruit and the absence of seeds as described by Rumphius indicated that this fruit might possibly be a navel type of pummelo. The purpose of this study was to clear up this latter point and to obtain plants if they still existed in the Banda and surrounding islands.

Scope of Present Investigation

During the present investigation, fruit of the double character was observed in the Banda Islands and on the Island of Ambon. The fruit season was not at its height in the Banda

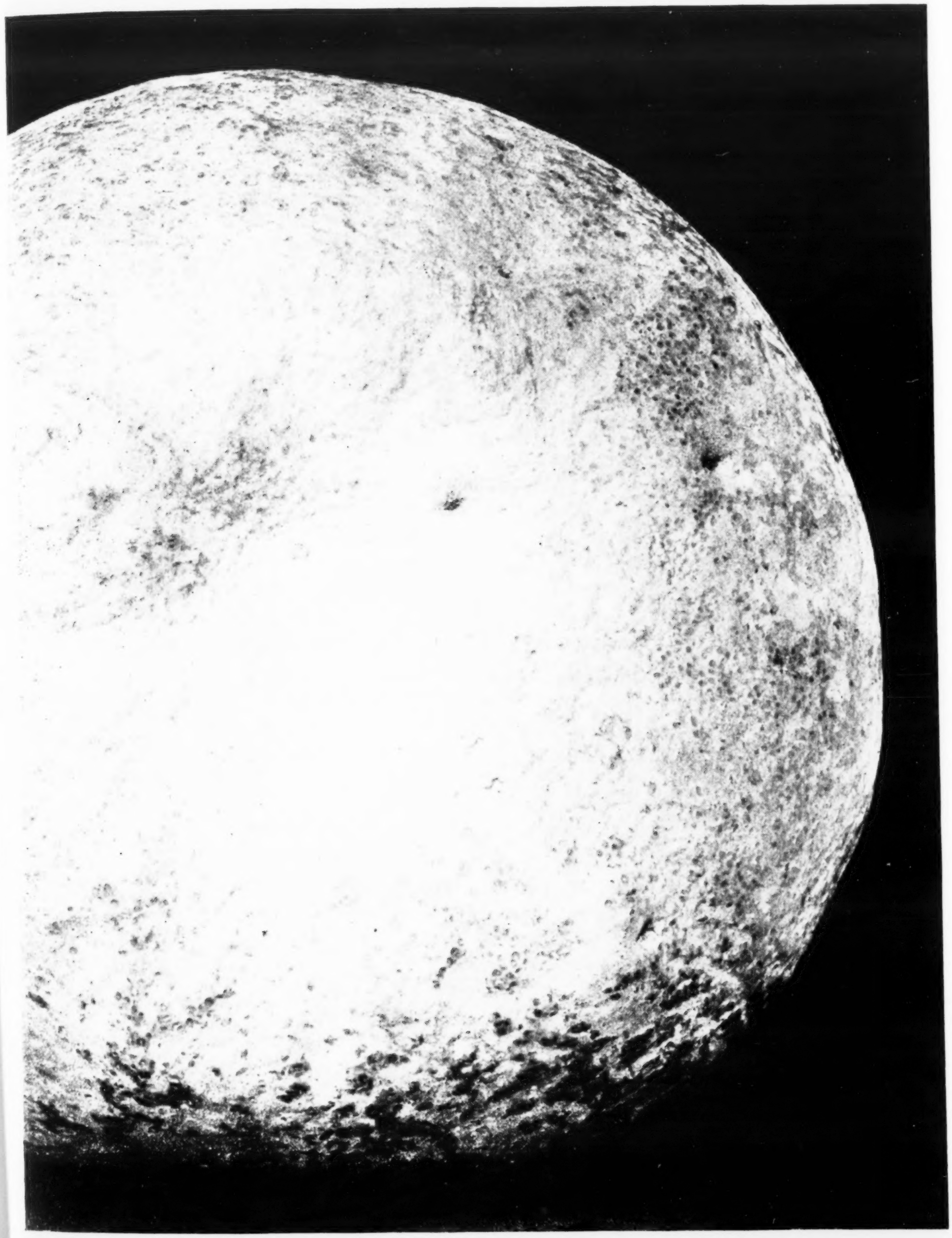
*Published as a contribution from the Research Department, United Fruit Company, Boston, Massachusetts.

†Rumphii, Georgii Everhardi. Herbarium Amboinense, Part 2, Vol. 34, Page 98, 1741.

CROSS-SECTION OF DOUBLE PUMMELO

Figure 1

Two sections through the same fruit, the section at the right is looking toward the stem end; the cut "rag" of the internal fruit can be seen. The section at the left is cut nearer the blossom end, and shows the small pummelo within the large one. There was only one seed in this



Two sections through the same fruit, the section at the right is looking toward the stem end; the cut "page" of the internal fruit can be seen. The section at the left is cut nearer the blossom end, and shows the small pummelo within the large one. There was only one seed in this fruit.

Figure 1

THE DOUBLE PUMMELO IS NOT A "NAVEL" FORM

Figure 2

Blossom end of an Ambon double pummelo, showing the absence of any external evidence that the fruit is double. Not all of the fruits on a tree are double, but it is impossible to distinguish "singles" from "doubles" by external appearance.

Islands, but on the Island of Ambon the trees were heavily laden. The double pummelo was also reported to be present in other of the Molucca Islands and was said to be especially abundant on the Island of Saparoea. The Department of Agriculture at Buitenzorg, Java, reported the double character as occasionally occurring in the Pandan Wangi variety, growing in the Pasar Minnggoe region near Batavia, Java.

While in the Banda group, the Islands of Banda Neira, Groot Banda, Goenong Api and Ai were visited. Although the months during which these investigations were carried out are in the height of the pummelo season in the Dutch East Indies, only few fruits were present on the trees in the Banda Islands. Enough evidence was obtained to show that the double fruit is still prevalent in the group. Only a few trees of this variety are now present on the Islands as little fruit culture is practiced. During the prosperous spice days of the Dutch East India Company, all available land in the Banda Islands was planted in nutmegs and practically all other crops were disregarded. The native population was very small and no large settlements were present. A large supply of fruit was, therefore, not essential. Apparently, the double types of pummelos were favored and retained. Each island has been divided into nutmeg plantations with their plantation houses and labor quarters. Today the only pummelo trees found growing are in the gardens of the old plantation house enclosures. Because of their scarcity, the history and fruit character of each pummelo tree growing on the island is well known. On the Island of Ambon, there are more citrus trees and the double pummelo is rather common.

General Character of Fruit in 1926

A number of different strains of the double variety are present in each locality, indicating that plants have been produced from the possible original type by means of occasional seeds developed in the fruit. The trees vary from the low spreading type to a taller, more upright type. The shape of the fruit varies from flattened to rounded and slightly raised at the stem end. The flesh varies from white, white and pink mixed, to all red. The leaf character of the trees is usually the same, each having a variety of pummelo type leaves. Generally, when the double character is present the fruit produces no seed. Certain trees were said to produce both double and single fruits without seeds. One tree in particular was reported to have consistently produced fruit of this type until the last crop, which was produced by the tree when it was in a weakened condition due to a long drought. All fruit in this last crop was reported to lack the double character and to be full of seeds. The tree died at the end of this heavy fruit production. A tree grown from a "marcot" taken from the above mentioned tree prior to its death, is now producing fruit mostly without seed and generally showing the double character. The double nature, therefore, apparently is not a constant character with all fruits on the same tree. It was reported that often only ten per cent of the fruits on certain trees showed this peculiarity, the other fruits being normal. One tree with many fruits examined on the Island of Ambon during the investigation had one hundred per cent double fruits and except in one case without seeds. The grower informed the writer that this was not by any means always true as in other seasons the fruit did not all show this character and more seeds might be produced. Evidently the double character is correlated with the seedless character in the individual fruits. More intensive studies will have to be conducted before this can be stated as a fact.

Comparison of the Fruit in Rumphius' Time with the Type Today

The recent investigation shows that the double pummelo type as described by Rumphius still exists in the Banda Islands, Ambon and other of the Molucca Islands and in the region of Batavia, Java. Evidently the fruit character has changed somewhat since 1741 owing to the production of trees from seeds whereby hybrid varieties were developed. The leaf characters of all the double pummelo trees examined agreed almost exactly with those described by Rumphius. The fruit character evidently has changed to a certain extent. The majority of the fruit examined during this investigation was more or less flattened or rounded. Only occasionally were fruits observed with an elevated stem end. Rarely were fruits seen that were malformed and tuberculed as described by Rumphius. In each case studied showing the tuberculed condition, this condition was due to the attacks of a rind boring insect, probably *Prays citri*. In certain localities, fruits were badly attacked and it is very likely that the tuberculed condition of fruit described by Rumphius was due to the attacks of this insect. The double fruit described by Rumphius had a white flesh, usually without seeds. All observed at the present time was of a red flesh or of a white and pinkish flesh mixed. White fleshed double pummelo fruit was reported to be still present on Poeloe Ai, but none of the trees examined had fruit. In any case, the double fruit produced at the present time is mostly of the red flesh variety. The red color character agrees with Rumphius' note on the fruit as originally grown in China. In none of the fruit examined did the small inner fruit have a part of a new skin produced on the top. The flower end of the fruit was always smooth and never showed the true navel character. Only rarely were double pummelo fruits found with seeds.

After having made a careful survey and study of this peculiar type of fruit one arrives at the conclusion that the double pummelo as first described by Rumphius is a definite type. In the Dutch East Indies it is peculiar to the Molucca Islands, being prevalent in the Banda group, in Saparoea and Ambon. Occasionally fruits are found in the Batavia region. All plantation owners in the Molucca region, who are interested in pummelos know this peculiar fruit and have noted special trees that bear the double fruit. While in the Banda group, the writer was always referred to the Island of Ai (Poeloe Ai or Plo-ay) as the place where the best fruit of this nature could be obtained. Thus, the Island of Ai still has the reputation of producing this fruit even though very few trees of this type are to be found there today. Even the same Malay names given by Rumphius are still used with the additional name of *Lemon pompelmoes*. The data for the following descriptions of the double pummelo trees, leaves, flowers and fruit were obtained from observations made on trees growing in the Banda Islands and on the Island of Ambon.

Description of the Double Pummelo of Banda and Ambon

Trees

Two general types of trees are found. The tree of the better type is 12 to 15 feet tall, low and spreading. The second type is inclined to be more upright and from 18 to 30 feet tall (Frontispiece). The taller type tree has strains that may be very heavy bearers, the larger ones, some eight years old, often producing over 500 fruits. A "marcot" from a tree of the small spreading type usually develops into a tree of the same type. Seeds found in fruits of these trees may, however, when planted, produce trees of the upright type. The double pummelo character, it is said, may also be lost in trees produced from these seeds. No spines are present on the branches

of typical double pummelo trees. The young twigs are pubescent, but as they grow older, they become glaborous.

The two trees in Frontispiece are fifteen to eighteen feet tall and according to reliable information often produce double pummelos. They were growing in a plantation yard in Poeloe Ai. The flesh of the fruit is white, tinged with red. Another tree from the same parent produces red-fleshed fruit; that from both trees is excellent and sweet. Young fruit examined from each tree did not show the double character.

One upright-growing type tree on the Island of Banda Neira was twenty-five feet tall. This tree was reported to produce red fruit of the double pummelo character. No fruit was present for examination, but the tree had the characters of the double pummelo type.

Only three trees of the double pummelo type were reported growing on the Island of Banda Neira. Some twenty-five trees were examined on Poeloe Ai. Most of these were reported as producing fruit with the double character.

Two special trees producing double pummelos were examined on the Island of Ambon. One tree was growing at Lateri, Ambon. It was fifteen feet tall and moderately spreading, with a tendency towards an upright growth. The fruit from this tree had a red flesh and all fruits examined (Figures 1, 3 and 4) had the double character. One hundred per cent of the fruit on the tree at the time of the examination was of a double pummelo type.

The second tree was growing in a private garden in the town of Ambon. The tree was 25 to 30 feet tall and was produced from a "marcot" of the preceding tree. The latter tree, however, was a more vigorous and slightly more upright grower. The character of its fruit was also slightly different. This is an extremely heavy bearing type having at the time of the investigation over 500 fruits. The fruit has a red, mildly acid flesh and shows the double pummelo character. It was stated that at least ten per cent of the fruit on the tree always showed this feature. All fruit examined exhibited the double character.

Leaves

The leaves are variable, generally large, oval or elliptic oval and with a broadly rounded base. The petiole is most commonly broadly winged, but some petioles may lack this character. The tips are generally rounded, but bifid or emarginate and pointed leaves are also found. The edge is non-serrate. The top surface is a dark, glossy green and the lower surface is glaborous and a lighter green. On the whole, the leaf type is similar to that described by Rumphius.

Flowers

Generally, eight to sixteen flowers are produced in clusters on the bearing wood portions. The flowers are fragrant, large, white in the bud, and with four petals that are white on both sides. Both the pistils and the stamens (with large linear anthers) appear to be normal.

Fruit

The fruit showing the double pummelo character varies in size and shape when taken from different tree strains. The most general type observed was the rounded to more or less flattened fruit (Figures 2 and 4), although trees bearing fruit that is slightly raised at the stem end are also found. In no cases of the fruits studied was there a new separate rind produced about the small inner fruit. The inner fruit was always separated from the larger fruit by a wooly membrane or rag. Both small and large fruit are of the same flesh color and flavor. Only red fleshed fruit of the double character was reported. The individual juice sacs are tough so that the fruit can be readily eaten out of hand without breaking the juice sacs. The outside blossom end of the fruit was always smooth and normal, thereby not show-

ing the true navel character (Figure 2). The skin is covered with foveolae and is usually rather thick and bitter. The double pummelo fruit rarely produces seeds. The fruits usually are formed in clusters.

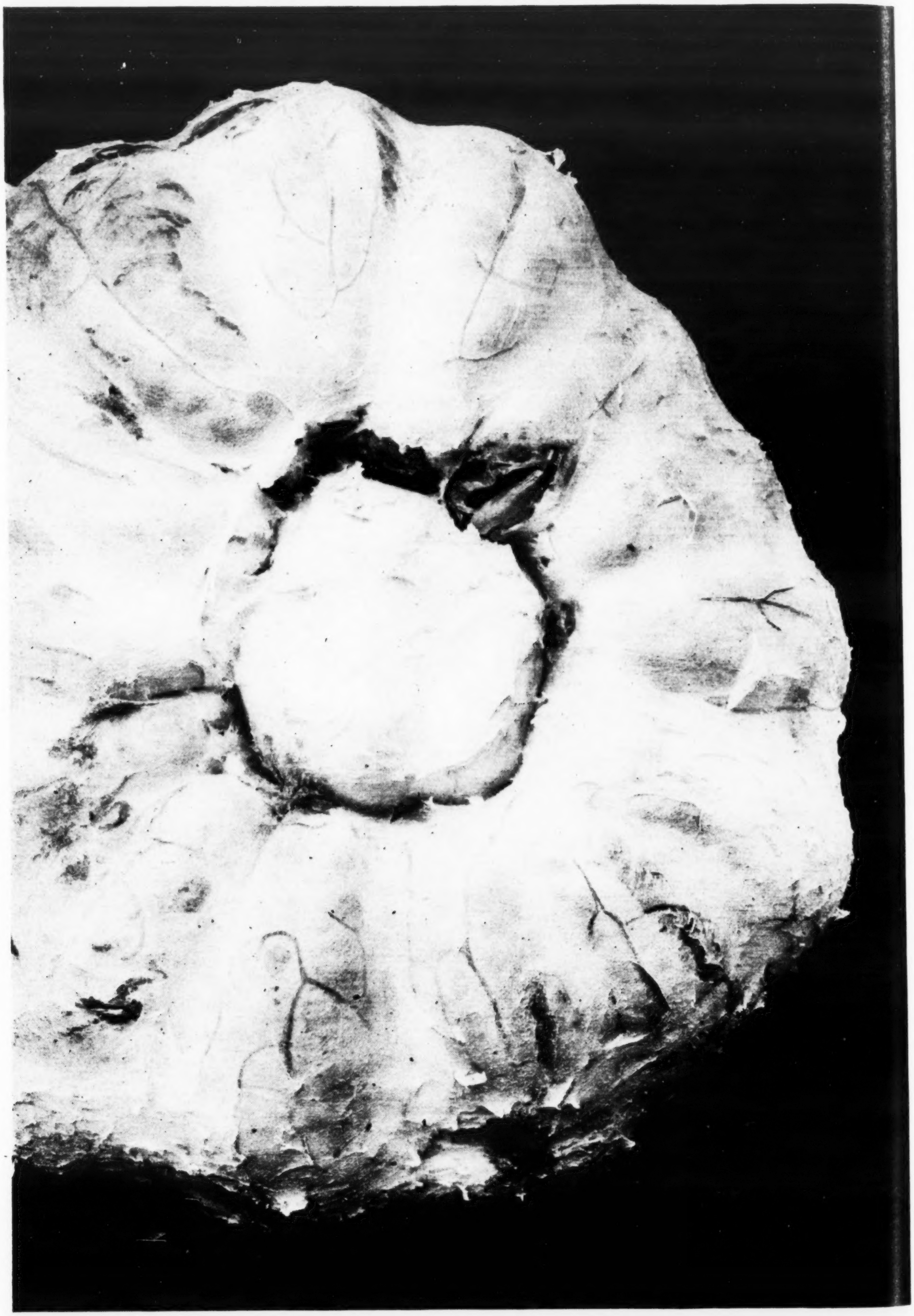
The shape of the fruit and the color of the flesh of the fruit are not exactly similar to that described by Rumphius. Either Rumphius secured fruit only of the white fleshed type or this type at the present time has become rare and hybrid types of white and red flesh and pure red flesh have been mainly cultivated. The double fruit character is still exactly as described by Rumphius except that no separate skin was observed as developed around the small inner fruit. The double fruit character was reported not always to be present in all of the fruits on one tree. This characteristic was also noted by Rumphius.

An average double fruit from the Banda Islands measured when not fully developed 6½ inches in diameter and was almost spherical but still with a slightly raised stem end. The external blossom end was smooth and normal. The fruit was young and not fully developed; therefore, the skin in proportion to the fruit appears thicker than normal. This fruit is produced entirely within the outer skin of the large fruit. No seeds were present. The fruit is of the red flesh type and is very sweet and juicy.

The fruit produced on young trees bearing their first small crop may be excessively large. One such fruit was reported to have weighed five kilograms. Another fruit taken from this tree in Ambon and examined during the present investigation measured ten inches in diameter. It was almost spherical, but slightly flattened at the blossom end. The skin was ¾ of an inch thick and the pulp of the skin was pinkish. The flesh was deep red, juicy and with a mildly acid flavor and had no seeds. The larger fruit had fifteen segments (locules) and the smaller fruit, produced at the blossom end, had seven segments. The small inner fruit measured three inches in diameter. This was an exceptionally large double fruit. The skin of the fruit when observed from the outside blossom end was smooth and showed no evidence of a smaller inner pummelo. When ripe, the skin is a pale lemon yellow. The average fruit from older, heavier bearing trees of the same type is smaller and usually inclined to be more or less flattened.

The majority of the fruits showing the double character were found growing on trees on the Island of Ambon. The following description is of fruit taken from one tree growing at Lateri, Ambon. The fruits from this tree were all more or less of the flattened types and measured 7½ to 8 inches by 6 to 6½ inches. They usually are well formed and with a smooth, sulphurous skin when ripe. Some had bumps or were tuberculed, as described by Rumphius, but these malformations were all due to insect injury. The outside, blosson end of the double fruit always had a smooth, normal skin (Figure 2). A side view of the Lateri, Ambon type shows the flattened nature of this fruit. The flesh of both small and large fruit was red and mildly acid in flavor. The internal double character of a peeled fruit is clearly shown in a series of photographs (Figures 3 and 4). Figure 3 shows the blossom end view with the small fruit in place. The view in Figure 4 is of a longitudinal section of the double fruit showing the large fruit with the small one in position. The large fruit had fourteen segments (locules) and the small fruit had four. No seeds were present. The small inner fruit is separated from the large by a woolly membrane or rag. No separate rind was produced about the small fruit.

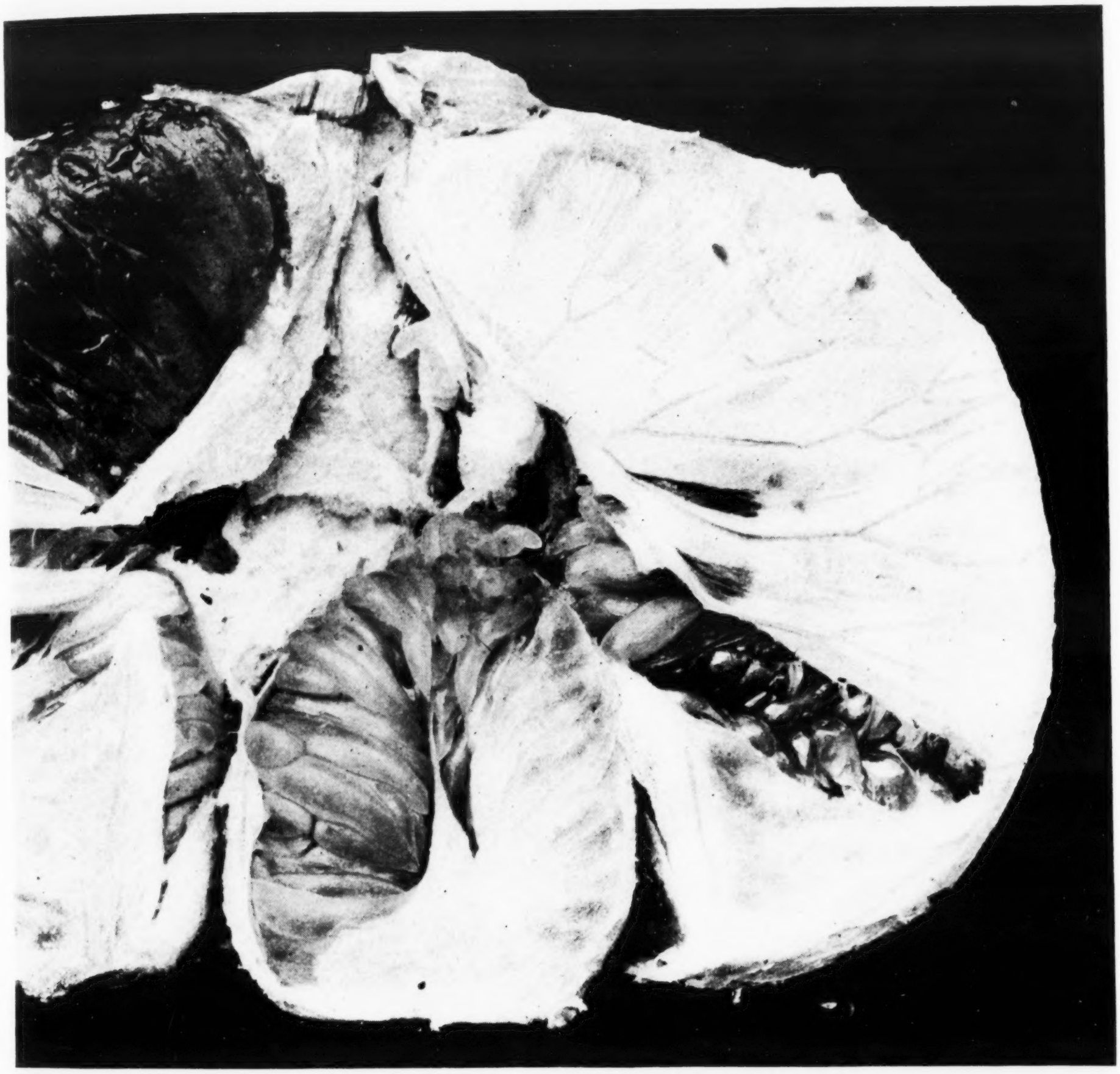
A further detailed study was made of five fruits collected at random from the Lateri, Ambon tree. All showed the double fruit character. The fruits were collected on August 28,



BLOSSOM END OF PEELED FRUIT

Figure 3

The small fruit had four segments, and the large fruit had fourteen. No seeds were present. The small fruit never has a skin of its own, in which it differs from the navel oranges. Approximately natural size.



LONGITUDINAL SECTION OF FRUIT

Figure 4

This is the same fruit shown in Figure 3. This view also shows the flattened shape of the fruit, and the large, easily separated follicles, both distinctive characteristics of pummelos. The follicles have skin that is tough enough so that they can be separated without breaking. The fruit can therefore be eaten out of hand without the occasional spectacular distribution of juice that adds an element of excitement to the breakfast grapefruit.

1926 which was towards the end of the normal pummelo season. Out of the five fruits only one had seeds and in this case only one seed was present (Figure 1). A longitudinal section of fruit "b" showed the small fruit almost in the center of the large. A cross section view of fruit "c" showed the small fruit at the blossom end and the cavity, and the cut rag of the small fruit, at the stem end. One seed was present. In no case did the small inner fruit have its own rind, and the small fruit was always developed within the smooth rind of the large fruit.

The fruit is often kept in very good condition for two months. During this time, the skin shrivels up and becomes thinner. The flavor is greatly improved by storage.

Method of Propagation

The trees are propagated usually by means of air layering or "marcot-

ting". When seeds developed in the double fruits they have been used for propagation purposes. The latter method undoubtedly produced new fruit types so that today a variety of flesh color types are found.

Diseases and Insects

Citrus canker (*Pseudomonas citri*) is prevalent on all types of the double pummelo growing in the Banda Group and Ambon. A bark rot was also observed. Its cause was not determined. The low spreading type of tree does not appear to be very hardy. The taller, upright spreading types are more vigorous. The rind of the fruit may be gnarled by the attacks of a rind borer, possibly the common *Prays citri* reported from the Philippines, although the identity of this insect was not determined. Scale insects of various types attack leaves and stems.

Summary and Conclusion

The double pummelo type, as described by Rumphius in 1741, still exists in the Banda, Ambon, Saparoea and other of the Molucca Islands, and in the Batavia, Java, region.

The fruit present in the island groups today is mainly of the red flesh type instead of the white flesh type as described by Rumphius. White fleshed varieties were reported to be still present. Evidently the fruit character has changed somewhat since Rumphius' time owing to the production of trees from seeds whereby hybrids have been developed.

The Banda double pummelo is undoubtedly a definite variety. Various types or forms of this variety exist, probably because of propagation from seed. The shape of the fruit varies from rounded to somewhat flattened. A rounded fruit type with a slightly raised stem end is also found. The flesh varies from white, white and pink mixed, to red. The leaf characters of all types are similar to that described by Rumphius. The trees vary from a low spreading type to a taller more upright type.

The double pummelo, apparently, is not a real navel type as the true navel characters were never observed to be present at the blossom end of the fruit and the double character is not constant with all fruits on the same tree. The flowers are perfect, with normal, healthy anthers and stigmas.

Fruits on trees showing the double pummelo character are inclined to be seedless. Apparently, there is some correlation between the double nature and seedlessness. At times, during adverse conditions, all fruits on a double pummelo tree are said to be full of seeds.

The double pummelo of Banda and Ambon would be a valuable addition to the citrus fruits now under trial in America.

Budded plants obtained from bud wood collected by the writer, of the various types described, are now growing at the Horticultural Experiment Station, Department of Agriculture, Passar Minggoe, Java, and two types are growing at the station of the Department of Agriculture, Manila, Philippine Islands. Arrangements have also been made for the introduction and trial in the United States of this interesting pummelo.

IMPROVED FOREST TREE SEED

A Suggested Study

PERKINS COVILLE

Associate Silviculturist, U. S. Forest Service

FOR a good many years a number of State Foresters, forest tree nurserymen, and men of the Forest Service have realized that a comprehensive study of forest tree seed sources for the ultimate purpose of improving the quality of such seed and, therefore, the quality of resultant trees, would be highly desirable. No one agency has felt that it had the time and money to go into the matter thoroughly, and so to date foresters find a serious lack of information regarding most of the phases of the subject. As one forest tree species after another has been intensively studied, occasional bits of data applicable to the problem have been brought to light but no constructive effort has been made to correlate this material. It would seem desirable to develop an active study of forest tree seed, because the whole subject is one for which a long time will be needed to produce real progress, to collect the information, to put it in practice, or to get it accepted by private enterprises; and because of foresters' increasing concern in the matter.

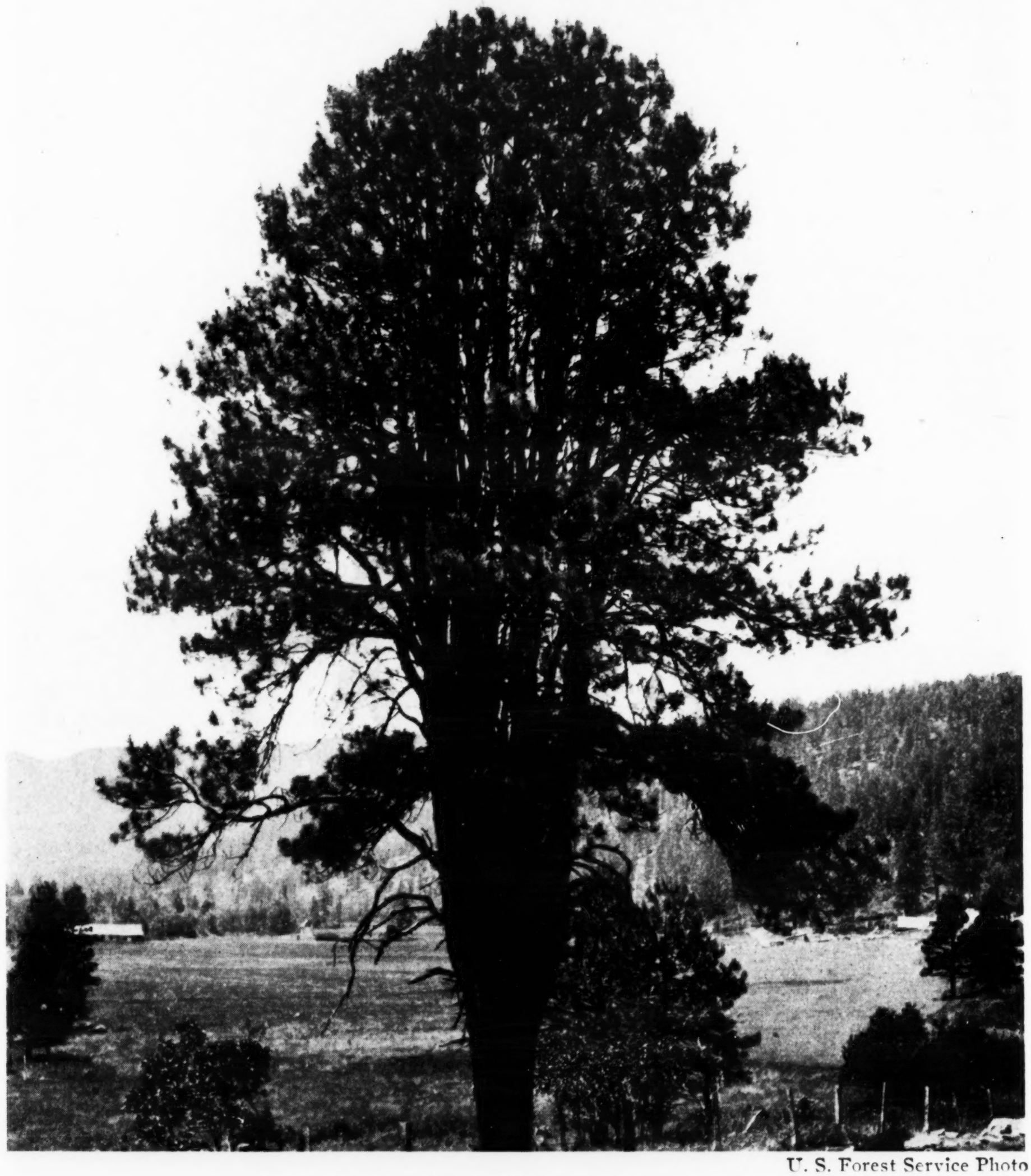
Although forest tree breeding may in time develop superior strains of trees from which sufficient quantities of seed may be obtained for fairly extensive plantings, there will be numerous complications, and tree breeding, at least for the time being, is to be considered as separate or divided from this matter of improved seed sources. Genetically, then, this study resolves itself into a study of tree qualities and characteristics, to find to what extent they are hereditary; and into selection, to obtain improvement. The main difficulties in this study will undoubtedly be that one should, first of all, determine what qualities or characteristics of a tree are due to environmental conditions alone, and what ones are truly hereditary,—secondly, that many of the trials will consist, of necessity, of growing trees to ages of from 20 to 50 years, before characters are sufficiently matured that one can make a definite correlation between parents and offspring.

Sources of Tree Seed

Much of the forest tree seed upon the market at the present time is obtained by seedsmen from scattered localities. To make money in a competitive business the conifer seed collector usually takes his cones from squirrel caches, from low bushy trees in the open, since the cones of such trees are more easily reached than the average, or, if he is fortunate enough to find a logging operation, from felled trees. The Forest Service in its own seed collecting operations has for years been addicted, through economic necessity, to robbing squirrel caches, buying cones at so much a bushel from Indians, and the like. It is unreasonable to expect any collector to confine himself to the collection of cones from large, vigorous, well-formed trees when easier collections are possible, unless he is to be paid for the additional difficulties and time necessary to do so. Apparently, no one has as yet seemed willing, except perhaps in a small way, to pay the additional price for this more expensive seed; no doubt it is unreasonable to expect any one to pay appreciably more until he can be shown that he will benefit at least proportionately.*

Forestry literature has numerous examples of what appears to be conflicting testimony in regard to the difficulty of separating environmental and

*Two seed companies are known that certify seed as to geographical source.

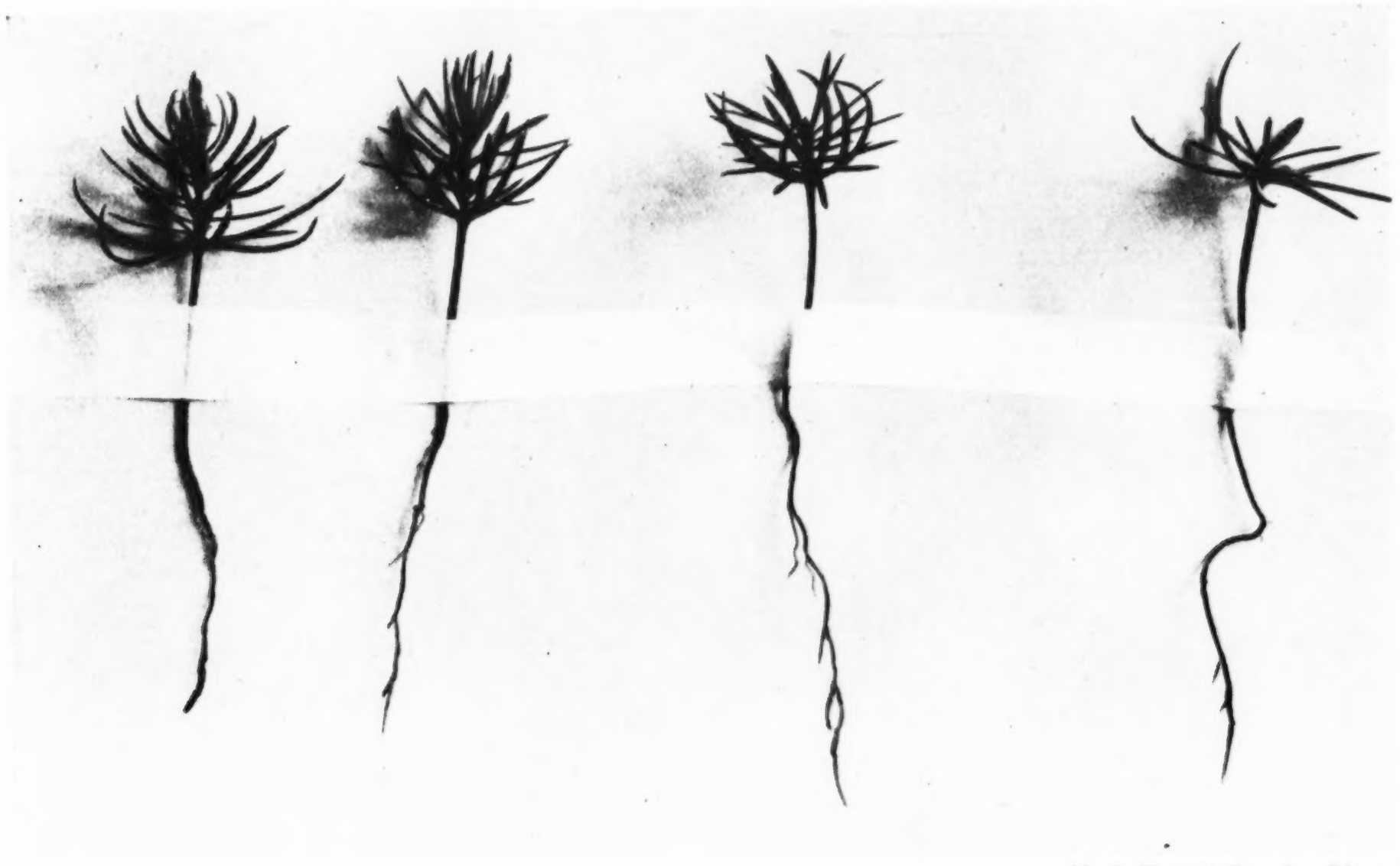


U. S. Forest Service Photo

A MUCH-BRANCHED WESTERN YELLOW PINE

Figure 5

To what extent are such characteristics as crookedness, forked trunks, and burls hereditary, when such characteristics are not the result of injury?



U. S. Forest Service Photo

Snoqualmie Pike Colorado

VARIATION IN SEEDLINGS FROM THREE NATIONAL FORESTS

Figure 6

Representative one-year-old seedlings of Douglas fir from three different seed sources. Grown at the Fremont Experiment Station.

hereditary characters. Dwarfed, stunted, or crooked trees are shown in one case to bear seeds which developed into trees of a like character; in another case, similar trees had offspring that were normal, of good quality; in still another case, offspring of poorly formed trees were found to throw off their poor qualities, when, and because cultivated. The statement issuing[1] from the Swedish Forest Experiment Station that trees of Scotch pine grown where the average summer temperature differed more than 1° C from that enjoyed by the parent trees, suffered seriously from the change, seems hard to believe when we know that Norway pine seed from Cass Lake, Minn., or like places, has been successfully used to produce planting stock to be used in Pennsylvania, Indiana, or Iowa, and that Douglas fir seed from both its "type" regions is widely distributed, both in the United States and in Europe.

Separating Heredity and Environment

That the study of forest tree seed will have to develop along two general lines, that of determining true heredity and that of determining the effect of environment, can be shown by illustration. If one chooses to consider some particular pure stand in a forest type, he might find upon field inspection that some part or parts of it appeared optimum for the species and that the trees were of splendid form, but that near the edges, where the type met with and graded into another type, the same species of tree was not at its best. If the area of the type were small and the species limited to it, the conditions of complete local cross pollination might be such that one could assume all the trees would be very similar in origin. Most differences in tree characteristics then would necessarily be due, we assume, to environment—the variations of the site factors of soil, moisture, competi-

tion, etc. One would like to determine, however, whether seed from the poorer trees would produce seedlings which would do equally as well as those from seed of the good trees a few yards away, if both were planted together on a *good* site. Some investigators approaching the subject for the first time might suggest that the poorer trees, having come from as good a source as the good trees, had merely been temporarily held back, and that their seed would do as well as the seed of the best trees if given a chance. Others might point out that there was the chance that the poorer trees, having grown for years on a poor quality site would not be capable of producing as good a strain of seed as the others. Similarly, on a *poor* site in the same immediate vicinity where planting was needed, would the seedling from seed of the trees on the good site or seedlings from seed of the trees upon the similar poor site succeed better? One group would perhaps argue that the good seed-tree progeny would have better vigor while the other would advance the theory that the poor site progeny were more perfectly adapted to the poor site.

Although the *survival* in a plantation may be good, the whole story is not told. In the long period between the usual last check on survival and the final harvest what kind of a stand will develop? The average tree planter's general satisfaction in a plantation is usually evident if he finds that, after a year or two, a good survival has been obtained; as if survival were all that is to be desired. In planting, trees or seeds have often been introduced far from their native ranges, with differences in latitude, soil, and climatic conditions. It is increasingly important that foresters determine more accurately what effect this disarrangment has. Many plantings are made upon severe sites, where normal conditions may have been upset by cutting, fire, brush cover, and drying of the site. In many cases the planter does not get a good survival, because of these severe sites, adverse seasons, rodent damage, poor planting, or, as one might even suspect, because an introduced strain from outside the region was used. Owners want the best stands possible, but apparently foresters are not using the best judgment in the matter. While one might admit gross ignorance upon many details of such matters, it still stands to reason that a certain lot of seed from a good local source, from a similar or perhaps better site, and from good trees, though it cost more than an equal quantity of seed from a distant or unknown source will prove more desirable. The price of northern white pine seed (*P. strobus*), whether it is $3 a pound for ordinary seed, or $6 a pound for special seed (assuming the seed has only a 50 per cent germination and that 1,000 trees are to be planted per acre), would only vary the final cost by about 25 cents per acre. This is a rather negligible factor when volume and quality at the time of a final harvest are considered. Without going into tree breeding, it is possible by selection over a period of years to improve planting stock, or by scientifically choosing seed trees (for natural reseeding of a logged area) to improve some of our naturally seeded areas. Until more is known about seed stored in duff, however, we can not always be sure that all of the seedlings appearing soon after cutting, have come from seed of the choice trees reserved for seedlings. The seedlings may be the progeny of poor trees, developed from seed borne and dropped before cutting.

It is desirable to test the hereditary characteristics of many qualities of trees such as growth rate, wood qualities, strength, density, and the like; susceptibility to various fungi, insects, wind and fire damage; and such abnormalities as "birdseye" and "curly grain" in some species, or resin production in certain southern pines. J. S. Boyce[2] has pointed out that some practices are not as bad as they seem. Overmature Douglas fir trees with heart rot, for example, might be consid-

U. S. Forest Service Photo

TAKING CONES FROM A SQUIRREL CACHE

Figure 7

One "Seed source" that will probably never be "Certified"

ered poor specimens to be left to seed an area; yet heart rot alone probably has little effect upon the living part of the tree. Even if the offspring should inherit a susceptibility to rot it is a factor of minor importance, as second growth will undoubtedly be cut before the age is reached when the disease would develop. Consistent selection of such trees might have the affect of intensifying the susceptibility, leading to earlier infection. Speculation is useless in the absence of more facts.

Probably many insects attack trees that lack vigor. H. L. Person's study of western yellow pine stands attacked by the western pine beetle[3] seems to prove that the bark bark beetle attacks suppressed or otherwise backward trees. J. A. Fitzwater has personally reported that various strains of western yellow pine planted at Halsey, Nebraska, showed decidedly different reactions under the attack of the Nantucket tip moth. Since those trees most seriously attacked were derived from a seed source some distance away, it seemed to reasonable to conclude that they were not as well adapted to the site as others derived locally, and that they therefore were not as vigorous and capable of resistance. This, however, is not true of all insect attacks, for it is the writer's personal observation that the white pine weevil, in attacking a plantation or other even-aged stands of northern white pine, first picks the most rapid growing and vigorous trees for its attentions.

Sources of Data

The most feasible way to determine the relation of parent to offspring and the limits to which such offspring should be confined is to obtain records

of past work where it is available and reliable, and to develop an accurate procedure for further work. It is now possible, no doubt, to find many plantations near each other, of the same species, but from seed of widely different geographical sources. Records of these might show that, for Norway pine planting stock for use in Pennsylvania, New York is a better seed source than the Lake States. That would give some idea of the optimum range of New York seed if the seed were all from trees equal in quality. If the Lake States' seed happened to be from poorer trees than the New York seed, however, the test would be valueless for who could then say that seed from the best trees in the Lake States would not prove better than seed from poor trees in New York and even give equal results with good seed from New York? In other words, it seems essential that one keep records of the qualities of the trees from which the seed comes, as well as records of the locality. Altitude, as well as latitude, will probably be found to have a great deal to do with success or lack of it. A well-formed tree that does well at a moderate altitude is no doubt a much better parent for stock to be planted at a lower elevation than a tree from low elevation is for stock that is to be planted higher up. In either case there must be limits beyond which it is unwise to go unless one *must* have the trees. Assuming that there are several sources, as there often are, one would like to know which will give the best results. Also in the case of cross pollinated trees, it would seem necessary that the source of seed should be isolated groups of trees that are all good, for trees that are of good quality, if fertilized by pollen from poor trees near by, may well produce seeds which in various proportions will develop into stock of very ordinary, or even poor, quality. This phase, in later years, when more is known about the subject, may, especially in the real breeding work, demand that certain seed sources be isolated from others of like kind, which are not as of high quality, so that the standard of quality can be met.

It seems to be beyond the power of one or a few men, to collect sufficient data, or to arrange for the continuity of the work in a way to make any real progress. It is essential that foresters have facts to prove to themselves, to say nothing of the public, what is necessary to improve planting stock. Because it is not desirable at present, at least, to have anything more than small experimental nurseries at most experiment stations, the work could well be augmented and increased by cooperation between interested organizations throughout the country. Many nurserymen are of an experimental turn; and given guidance and instruction along appropriate lines such that all effort would lead to the same end, and not to uncorrelated results, much could be achieved. Those persons who plant trees extensively, anxious to have answers to their own baffling questions that have arisen from past experiences, would be glad to cooperate if the work could be arranged so that it fitted in with, and more or less paralleled, present nursery, seed collecting, and planting practice. In many cases results of past planting would be greatly enhanced if one merely had a few more specific facts as to the source of seed, kind of parent, locality, and the like.

Standardized Procedure Important

A study of this kind, while it must certainly be considered feasible, must be correlated by means of suitable instructions and record sheets. These record sheets could be standardized by agreement and arrangements made so that a complete file could be kept by some interested organization which shows the greatest likelihood of permanence. Compilation of results over periods of years will allow scientific conclusions to be drawn on the basis of the original data and subsequent development.

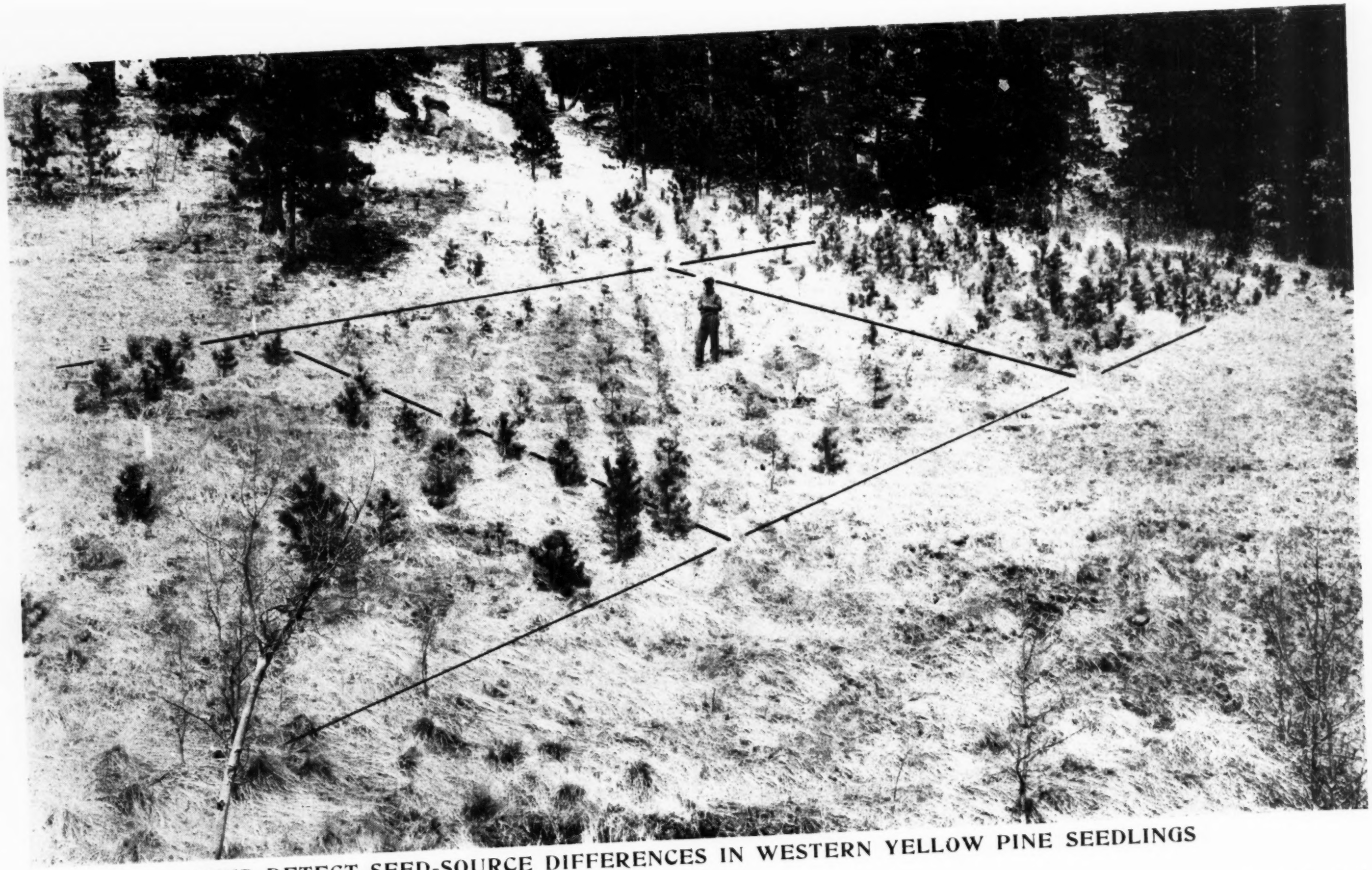
It seems appropriate that one should

U. S. Forest Service Photo

A WESTERN YELLOW PINE SHOWING AN UNUSUAL DEVELOPMENT OF WITCHES' BROOM

Figure 8

Is susceptibility to mistletoe and other forms of injury hereditary, or the result of environmental conditions, or both?



DEER DETECT SEED-SOURCE DIFFERENCES IN WESTERN YELLOW PINE SEEDLINGS

Figure 9

Deer, in their grazing, have distinguished between stock derived from seed that came from the Black Hills (center plot) and stock that came from Leadville and San Isabel seed sources (shown on either side). If the seedlings differ to this extent why should they not show differences that will influence economic values?

begin tests upon three classes of parent stock, the best, the medium, and the poorest, for purposes of getting the greatest contrast and checks. The parent stock should preferably be such that there is as little a chance as possible of its being pollinated by pollen of any trees but those of like kind. Since pollen will blow for very great distances in periods of high wind, this factor of the source of pollen will be a weak point in the investigation. Only by hand pollinating, covering the female flowers with sacks and leaving checks can we be absolutely sure of the source of pollen. Since we are dealing with a project to improve seed by natural pollination, this artificial manipulation might seem superfluous, but some of it would be especially valuable because it would allow closer checks upon heredity than we can get otherwise. When seed production upon a larger scale is to be undertaken, we must take our chances upon pollen source, no doubt trying to protect the trees from stray pollen by screens of other trees when possible.

Where practicable, regional projects should be started and given over to the administration of one man, who would be responsible for supervising and correlating all studies in his particular region. In order to come to reasonably universal conclusions for the whole study, variations in individual studies must be limited so that the various regional projects will be carried out in essentially the same way.

The records for such a study as is suggested should cover in considerable detail such main headings as: Location of seed source; data upon site qualities and factors; detailed description of the parent stand, and the seed trees; the characteristics of the seed crop; data on seed extraction, cleaning and storage procedure, temperature, humidity, and time; pertinent data on nursery procedure when raising the progeny; and planting site description and planting procedure.

Such initial work as is here suggested would lead the way to later detailed records on the test areas which will yield data on survival, vigor, rate of growth, heredity, etc., correlated as much as possible with data obtained previously, the correlation of progeny to parent.

Developments, resulting from a widespread study of this character should allow us to certify seed in future years with much more assurance than present trends seem to justify. Certification of tree seed, if it is to have any practical value, must be based upon known facts, most of which facts at present we do not possess.

It is encouraging to know that some developments of a similar nature are already under way. The Eddy Tree Breeding Station at Placerville, California, is turning all its efforts to the breeding of strains of western yellow pine—both pure and hybrid. The prospects of the work under the direction of Lloyd Austin appear very promising. Information on seed sources and heredity are obtainable in a study of this kind. In addition there are activities in the United States Department of Agriculture and one or two botanical gardens and institutions. The development of more aboreta each year is a promising note, showing increased public interest, and indicating the feasibility of definite permanent areas where careful studies can be made. All in all, circumstances appear much more auspicious than ever before for research projects designed to improve forest trees.

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Deer, in their grazing, have distinguished between stock derived from Leadville and San Isabel seed sources (shown on either side). If the seedlings differ to this extent why that will influence economic values?

AWARDS OF HONEY LOCUST PRIZES

AFTER some delay in the hope of being able to obtain exact sugar analyses of the material submitted, the prizes for honey locust beans announced in 1928 are awarded to the following:

First Prize, J. M. Davis, Route 1, Fingerville, S. C.
Second Prize, Mrs. H. L. Eames, R. F. D. 3, Ridgeway, Va.
Third Prize, S. G. Foxworth, Sandy Hook, Miss.
Fourth Prize, Mrs. W. O. Lewis, Calhoun, Ga.
Fifth Prize, Bonnie Cline, Route 1, Pikeville, Tenn.
Sixth Prize, F. M. McCullough, Fair Port, Va.
Seventh Prize, Miss Nora Jenkins, Brush Creek, Tenn.
Eighth Prize, Wm. M. Arrington, Route 1, Box 31, So. Boston, Virginia.

The prizes were awarded on the basis of size and thickness of bean, weight of bean, and sweetness and palatability as determined by taste.

A large number of samples were received from widely separated locations, but none from regions not embraced in the earlier contest.* None of the beans submitted were any heavier than the previous prize-winners in the earlier contest, though some of them were longer, the longest bean being 22 inches. Some of the dried beans submitted in this contest have a much better flavor than any so far obtained, without as much of the irritating after-taste characteristic of most dried Honey Locust pods. It is noteworthy again that none of the samples submitted from Northern states in any way approached the better samples from the South. Professor J. Russell Smith has recently reported that grafts from the Georgia prize-winning tree has survived one Connecticut winter, which would indicate that the "fatback" type is not limited to its present range by temperature. In two cases, at least, rather extensive cooperative searches were undertaken: by members of the Burroughs Club of Hawthorne School, Yonkers, N. Y., and the Science Club of Hellertown High School, Hellertown, Pa. Their failure to locate any trees producing a fatback type of bean and the fact that none were submitted by other contestants in the North would indicate that this type is not to be found, or at least is very rare, north of the Mason-Dixon line.

A Challenging Field For Research

The two Honey Locust Contests sponsored by Prof. Smith have produced some valuable facts and located several trees that might well be the basis of sugar-yielding varieties. The Contests have evoked more questions than they have answered, and the material on hand should offer the basis for worthwhile research in a practically untouched field. As far as we are aware there are only two published records of sugar analyses of the pod. The other literature of the Honey Locust is equally meagre. In one case, at least, the beans used were dried under a variety of conditions, some of which may have reduced the sugar content. Nevertheless, the best samples were found to be nearly one-third sugar. Nothing is known about the inheritance of suger percentage in the Honey Locust and little about the propagation of desirable strains. A start on the propagation problem has been made by Prof. Smith, but much more needs to be done. The need for an erosion resisting tree-crop agriculture was stressed in announcements of the two Contests, and the need still exists. Thus research with regard to breeding, propagation and selection of sugar-bearing honey locusts is a project that would yield much of scientific interest, and perhaps even more as a practical measure for conserving of our greatest asset and one not readily replaced, for which there is no substitute—arable soil.

*Reported in JOURNAL OF HEREDITY 19:216-224. 1928.

THE LEUNBACH FAMILY

A Danish Family with American Indian Blood

O. A. Merritt-Hawkes
Birmingham, England

A FRENCHMAN who lived about 1770 in the West Indies, probably in the Virgin Islands of the Lesser Antilles, mated with an Indian woman and had at least one daughter, designated 1 in the portrait-chart (Figure 10), who married a Dane named Hjardamaal. Judging from her photograph and a painting which is in Copenhagen, this Half Caste daughter looked very much like a Carib Indian (compare her photograph with that of the pure Carib woman (Figure 11). It is probable that her mother was a Carib, for that was the race of Indians who then lived in the lower Antilles. The colour of the skin and general facial type in this family suggests that the Indian ancestor was a Carib. The resemblance of 1, 16, and 27 (Figure 10) to the Caribs in Figures 12 and 14 is very strong. The Caribs had migrated from the northern mainland of South America to the Islands, conquering the native Arawaks, massacring the men and mating with the women. It is believed that the Caribs had reached as far north as Hayiti when, in 1492, Columbus landed on Watling Island.

A. Hyatt Verrill says that at present there are many pure-blooded Caribs on the mainlands of South and Central America, especially in Guiana and Venezuela, but in the West Indies they are now only to be found on the Islands of Dominica (British), Trinidad and St. Vincent. Authorities differ considerably as to the colour of the skin of the Caribs and as to their present distribution.

Mr. Hjardamaal is believed to have been of pure Danish descent and had blue eyes. There is no tradition as to the type of the Frenchman who mated with the Carib woman nor in what island he lived, but, as the Half Caste woman had two children with blue eyes, 4 and 10, her French father must either have been blue-eyed or have been heterozygous for eye colour.

The features of the Half Caste, 1, show clearly that some Indian characteristics are dominant over the European. The question of dominance of the Indian type in other families will be discussed later.

The Indians of North and South America although of the same general type, vary in colour and in a number of anatomical details. The characteristic features of face and body that distinguish American Indians (this term is used rather than Red Indian as the latter, though popular, is hardly accurate), are as follows:

1. A greater breadth of the face as compared with the Whites. Boas gives the width of the Indian face as 150 mm. to 151 mm. and of the White as 140 mm. to 141 mm. and states that the Indian-White cross has an intermediate measurement, but is nearer the Indian than the White.

2. The eyes are slightly mongoloid, but the characteristic eye fold of the real Mongol is not often present in American Indians, although it occurs in Esquimos. It seems probable that this is due to both Indians and true Mongolians having originated from the same primitive race, but the Esquimos are a later immigration into America, having left Asia when the Mongolians as they are today, had developed some of their more specialized characteristics.

3. The teeth are typical, the incisors, especially the upper central incisors, shovel-shaped, the molars five cusped and there is an edge-to-edge bite. A shovel-shaped incisor is one in which there is a fossa or concavity on the lingual side, the edges of the fossa being made by thickenings of the enamel. This type of tooth, although

TYPE

Indian

Suggestion of Indian

European or Danish

EYES

Dark

Grey-Hazel

Blue

HAIR

Dark

Red

Medium

Blonde

Red-blonde

French

2

3

4

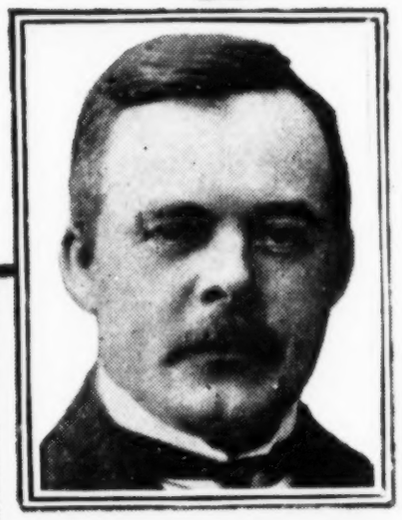
5

6

11

12

13



14

15

22

23

24

25

INDIAN CHARACTERISTICS DO NOT DIE OUT

Figure 10

A Portrait-Chart of a family tracing back to a Carib ancestor five generations ago. The symbols under the pictures are a key to type and to color of eyes and hair; the individuals who have married into the family (*2*, 13, 15, and 17) are distinguished in the chart by a white outline. In the fifth generation the "Indian" characteristics are still definitely Indian—there seems to have been no weakening of them during a century and a half in Northern Europe and through four out-crosses to blue-eyed, light haired Europeans. The cousins "16" and "19" are said to look exactly alike; "6" and "14" are the only persons in the ancestry whose hair is not perfectly straight.

supposed to be due to the hard dental work correlated with a more primitive type of life, has nevertheless persisted even in those highly civilized Mongolians, the Chinese and Japanese.

4. The nose varies considerably in shape, not being as frequently aquiline as is popularly supposed. An aquiline nose occurs in some districts in China so that it is not a development of the Indian during the presumed 10,000 years that he has been isolated from the parent Asiatic stock.

5. The skin colour varies from tribe to tribe, there being every possible shade from yellowish through reddish to chocolate brown. Verrill says, "The Carib is yellow rather than brown and with pinkish or reddish tint in the cheeks and with red lips. When mixed with Whites the cross is slightly darker than an ordinary brunette but has the pink cheeks and red lips of the Caucasian."

6. The hair is straight, lank and black, but not as coarse as is usually supposed. In cross section it is circular. I have not been able to get information on this point in the Leunbach family.

7. The eyes are dark or are even called black by some observers.

8. The cheek bones are high.

9. The hands and feet are relatively small compared with those of Whites. The nails are a dullish blue.

10. The body and face hair is scant compared with Whites, but many Indians could grow a small moustache if they did not pull out the hairs. The Carib Indian (Figure 14) shows the same amount of moustache as the Indian-like Danes, 16 and 6. Beard and axillary hairs are almost non-existent.

The recorded ethnological facts about the American Indians are often contradictory and it may be that some ethnologists will not agree with the above ten points. As there are so many ways in which the two races differ, very interesting results could be obtained if only there were enough data. Although this photographic rec-

A CARIB WOMAN

Figure 11

The Carib ancestry in this Danish family traces to a Carib woman five generations ago. The woman shown here is from Guiana, and is an example of the Carib type.

ord is so complete, photographs, unless taken under strictly comparable and controlled conditions and for both full face and profile, give very false impressions as regards hair and eye colour and no information at all about nostrils, teeth, comparative size of hands and feet and skin colour.

The Indian-White Hybrid

Boas says, speaking of the F_1 generation of the cross between the Indian and the White: "The face of the offspring has a tendency to reproduce one of the ancestral types, not an intermediate type." This is not true of this Leunbach family or of the numerous Win families described in *Mongrel Virginians*, where the F_1 generations are Indian in appearance and the segregation occurs in F_2. The term 'Indian appearance' is very vague, as it may be due to a combination of factors which differ with each individual. Throughout this family, however. the Indian appearance is due to the combination of dark hair and eyes, very straight hair, shape of eyes, cheek bones, nose and mouth.

Fischer finds in crosses between Boers and natives, that "The several traits of each component race are trans-

Photograph by A. Hyatt Verrill

CARIB AND "1-16TH CARIB" CHILDREN

Figure 12

Carib children from Guiana (right) compared with the "Indian" boy designated 27 in the chart.

mitted quite independently of one another in racial hybrids," but in this family there is considerable correlation between hair and eye colour, shape of cheek bones and breadth of nose. There is one exception, 14, where the hair is red and the eyes grey, although the top part of the face is anatomically Indian. Boas' papers also suggest that he found correlation. Virchow did not find complete correlation between light hair and light eyes among Jews, there being from 15 to 26 per cent more of them with light eyes than with light hair in Germany, Austria and England. There is certainly not complete correlation between skin and eye colour in many hybrids between Whites and the darker races, and Gates says as the result of his work on Esquimo-White crosses: "The hypothesis is suggested that certain factors for melanin pigment in the skin produce it also in the eyes, while others do not affect the eye pigmentation." The facts in most cases would seem to fit exactly the opposite hypothesis, as the eyes are dark in cases where the skin is pale.

In the numerous Win families recorded by Estabrook, there is constant correlation between hair colour, eye colour, skin colour and facial anatomy, so that even when there is only an eighth of Indian blood the descendants are called 'typically Indian.' In a number of faces in this Leunbach family the resemblance to the European or to the Indian type is quite clear, but it is difficult to define satisfactorily what makes the likeness. In merely looking at the photographs there may be considerable divergence of opinions as to which persons are a little and which much like Indians, but decisions were made on the combined results of a study of the photographs and statements made by a member of the family.

The Half Caste woman, 1, married a fair-haired, blue-eyed Dane, 2, who is believed to have been of pure Danish stock, and they had six children (generation 3). Of these, two were Danish type—one a male, 4, had blue eyes and blonde hair; and the other, 10, was a girl who died young, but a painting shows her with blue eyes and reddish blonde hair. There were three daughters, who all had dark hair and eyes; two of them, 3 and 8, were partly Indian in appearance, but the third daughter, 5, was very Indian, being, years after this photograph was taken, almost a replica of her mother. The remaining child, a son, 6, had brown hair and eyes, but the shape of the forehead, eyes, nose and breadth of face suggested the Indian.

In this generation there is definite segregation, the Danish type appearing in two children, 4 and 10, the Indian in one, 5, and the remaining three are intermediate. This family confirms what Boas has found, that the American Indian-White cross shows no signs of reduced fertility. His observation that there may be greater fertility than in either parent race is borne out by the enormous families of the Wins. He says that such hybrids are taller than either parent race, but does not state whether the extra height persisted after the F_1 generation. On this point there is no information for this family or the Wins. I also found increased size in the F_1 generation of moth crosses.

It is impossible to judge accurately the width of the face from photographs taken under such varying conditions, but it may be that the existence of such width is an important factor in producing the resemblance to the Indian.

Boas says that in a family where there is three-fourths Indian and one-fourth White; that is, *the opposite of this generation 3*, the influence of the White is very slight, but here also and in the Win families, because some of the Indian characteristics are evidently dominant, the influence of the White is slight.

Jenks writes: "The tendency is for the individual to assume the physical characteristics of either of the parent stocks in direct ratio with the preponderating inheritable influence of that stock over the other parent stock—a hybrid individual of three-fourths White and one-fourth Indian blood will bear measurable characteristics more like the White parent than the Indian." Such a statement is, no doubt, made on individual observations, but not on the study of such a family record as the Leunbach's family tree.

The daughter, 3, of the above family, who had a somewhat Indian appearance in shape of eyes, forehead and cheek bones, as well as dark hair and eyes, married a blonde, blue-eyed Dane, 2, with an exceptionally long face. They had five children, two Danish in type, 11 and 12; one intermediate, 14; and two "Indians;" 16 and 18 (generation 4).

The daughter, 11, was the same type and colour as her Danish father; the daughter, 12, was Danish in type, but had blue eyes and red hair; the daughter, 14, has nose, cheek bones and eyes of a decidedly Indian type, but the eyes were grey and the hair red. This is the only person in the family in which there is no correlation between partial Indian anatomy and dark hair and eyes. I do not know any references to the appearance of red hair in White-Indian crosses, but its appearance would be expected. Red hair is found in the West Indies, where there are White-Negro hybrids, and also in crosses between Caucasians and Jews.

A "CARIB" AFTER THREE GENERATIONS

Figure 13

Profile view of "16" in Figure 10, showing the perpetuation of Indian characteristics. The alleged disappearance of Indian traits in race crosses is probably to be explained by assortative mating, non-Indian segregates being selected. It will be noted in the chart (Figure 10) that the "Indians" trace back through "Indians" to the Carib progenitor. The "Danish" segregates uniformly produce blonde children, and in these lines the Indian characteristics do disappear in a generation.

The remaining children, 16 and 18, were very like Indians. The male, 16, is Indian in everything except possibly his jaw, and the woman, 18, is as Indian as her aunt, 5, or her grandmother, 1. There has been no alteration of the dominant Indian genes even after two generations in a northern European country and after two matings with blonde, blue-eyed Danes.

The man, 16, is the first male of

Photographs by A. Hyatt Verrill

CARIB TYPES

Figure 14

At left is a Carib from Panama; at right a Guiana type of the same tribe. It is interesting to compare the full-face view of the Panama Carib with the one-eighth Carib individual designated "16" in the chart. (See Figure 13.)

almost pure Indian type, and he appears in the third generation after the Indian great-grandmother.

Returning now to generation 3, the male, 6, married a fair-haired, blue-eyed Englishwoman, and they had one son, 19, who was Indian-like in both anatomy and colour. This resemblance does not show very well in the photograph, but he is said to have been almost exactly like his cousin, 16, who has such an Indian appearance that he is frequently taken for a Japanese or Indian. The male, 6, and his English wife were genetically the same types of mating as the female, 3, and her Danish husband, 2, except that the sexes were reversed.

Again in generation 3, the female, 8, married a Frenchman, in whom there was some negro blood, and they had a son, 20, who is described as neither Indian nor European, but "very mixed up." There is a considerable resemblance to the profile photograph (Figure 13) of his cousin, 16. This man, 20, married a French woman, who had a little Jewish blood, and they have a baby, 28, who, on account of her appearance was at once called "The Indian Baby," for this family has learned to expect an "Indian" to appear. This child has strong suggestions of negro as well as Indian blood.

In generation 4, three children of the mating 2×3 married. Number 12, a Danish type with European features, blue eyes and red hair, married a Dane, 13, with medium brown hair and blue eyes. They have three children, all European type, all with blue eyes; one has fair hair, one reddish blonde and one medium brown. This mother was a segregate Danish type, she married a Dane and had three Danish children, without any sign of Indian blood appearing. This small group as well as the remainder of the family

history suggests that the Danish (European) type is recessive in facial characteristics. This is, unfortunately, the only marriage of this type in this family.

Number 14, a red-haired, gre··-eyed, partly Indian type, married a Dane with dark eyes and brown hair, and they have one child, 25, a Danish type with blue eyes and reddish blonde hair. His hair is the same colour as that of his cousin, 23, whose mother also had red hair and the father was brown-haired.

Number 16 married a Danish woman, 17, with blue eyes and medium brown hair. They have two boys, a typical, medium fair-haired, blue-eyed Dane, 26, and a second boy, 27, as Indian in appearance as his father, 16.

There is here, in generation 5, this child, 31, who is very like a pure Carib child (Figure 12) from Guiana. Estabrook says of one of the Wins: "Mich had only one-quarter of Indian blood, but his physical characteristics would place him as an Indian at once"; also, "The persistency of Indian traits among the Wins appears remarkable when the remoteness of pure Indian blood is taken into consideration."

In this complete photographic record of a family, which I owe to the kindness of Dr. Leunbach, there is segregation and the heterozygous type, even in the fifth generation, shows some Indian characteristics as clearly as in the second generation. Ruggles Gates believes that at least two factors for brown eyes are necessary to produce the intense "black" eye of the Indian and that probably there are three or four such factors. Numbers 16 and 27 seemed to me to have this "black" eye but possibly one cannot be sure of this unless there is an Indian on the spot with whom they could be compared, and it is three years since I saw ar American Indian. Tradition says that the same intensely dark eye occurred in 19, 18 and 5. If these people did have the "black" eye there must be some close association of the factors for eye colour, for there is no evidence historical or genetic that the Indian blood came from anyone except the Half Caste woman, 1. There is also no evidence that there is negro blood except in 20 and 28.

There appear to be no sex linked characters.

The adult Indian-like males, 6, 16, and 19, all have less hair on their faces and bodies than the average European. The American Indian certainly has less hair than the European, but the amount varies from tribe to tribe. Some have a few hairs on the chin which may grow quite long, but the exact facts about distribution of hair is difficult to determine as many Indians habitually pull out face hairs as soon as possible. As stated earlier in this paper, most Indians would have a slight to moderate moustache and some beard if they allowed the hairs to grow.

Indians always have straight hair on the head, but in the Leunbach family are two people with wavy hair; the partial Indian male, 6, and the partial Indian woman, 14. The very slight curliness of the latter was natural but there are no data about 6. I have not been able to find whether, at that period, men ever had their hair waved artificially as they did thirty years earlier and as they do today, but the photograph suggests the hair dresser

The original Half Caste woman, 1, is said to have had a deep brunette skin but such never appeared again; there is certainly not great correlation between eye colour and skin colour. The Indian-like men and women were never rosy, though a little colour might appear at times in their faces, their skin being as a rule rather Japanese in appearance. The lips are reddish. American Indians are said to have thicker skins than the Whites, but a member of this family does not consider that the "Indians" have a thicker skin than the Danes. Dr. Verrill says of the Caribs: "The Carib is yellow rather than brown and with a pinkish or red-

dish tint in the cheek and with red lips". I do not know whether this means that the Carib has a thinner skin than most American Indians. Verrill also writes, "When mixed with Whites the cross is slightly darker than an ordinary brunette, but has the pink cheeks and red lips of the Caucasian". Gates considers that at least two independent pairs of factors for skin pigmentation must be involved and this family supports his contention, but in the Win family there is a persistence of the copper colour even when the people have only one-eighth of Indian blood. We may be dealing with very different genetic values in skin colour in the different races or sub-races.

Boas says, "The nostril of the Indian is round and bordered with thick alae while that of the White is elongated and have fine alae, in the cross the nostril is narrower and the alae thinner, thus producing a narrow nose". The most clearly Indian types, 5, 16, 19, 27, certainly have a nose thicker at the end than their relatives, though one hesitates to decide about such a detail from the old photographs. The photographs do not show the shape of the nostrils and the individuals examined did not have round nostrils.

I have no evidence about the teeth of the family except that 16 and 27 are reported not to show any signs of the shovel shape.

Degeneracy In Race-Crosses

There has been no degeneracy in this family as the result of the mixture of Indian blood, on the contrary, it is superior physically and mentally, although out of twenty-one persons six are Indian type, five are partly Indian and ten only are pure Danish type. This confirms what Finch says, "that the crossing of races is by no means necessarily bad, although there is a general feeling that this is so", and further he adds, "The product of blending of Negroes, Spanish and Portuguese with Indians forms a large fraction of South America". Boas also writes, "The mixture of the Spaniard and the Indian has produced the excellent modern Chilian". I do not know how far assortative mating has played a part in Chili. In the production of a superior race from crossing much must depend upon whether there is a correlation between certain physical features and certain intellectual and moral qualities, if, in selective mating, physical features play the larger part in the choice of mates.

Madison Grant expresses another point of view, "Whether we like to admit it or not, the result of the mixture of two races, *in the long run,* gives us a race reverting to the more ancient, generalised and lower type. The cross between a White man and an Indian is an Indian——". This is scientifically not true, for the results, "in the long run" are due to further matings and to selective mating factors. What socially so often happens is that the half-caste finds its home among the lower race (the term is used with the usual social meaning) of its ancestry. The cross produced by the Indian woman and the White man, for that is the usual mating, tends to return to the Indians and mate with Indians. It is only rarely that such a family as that described in this paper occurs, but in Denmark there is far less social feeling about non-European races than in most European countries.

Davenport writes, "A hybridised people are a badly put together people and a dissatisfied, restless and ineffective people". Such deductions would have to be drawn from Mjoen's work on crosses between Nordics and Mongolian Lapps, but they are not true of this family which is a cross between Nordics and Mongoloid Indians. We have not yet enough data for such a general statement.

The history of the Bonin Islanders is of great interest. In 1830 Bonin Island was settled by American and Polynesian men and only Polynesian women. The first generation, from the mating between the Polynesian women and the American men had features which were European. The Polynesian

black hair and eyes were dominant and the skin was intermediate. In the next generation there was segregation into Polynesian and European types. In 1860 Japanese settlers arrived and as they are dominant over Whites and Polynesians the inhabitants of the islands have again altered racially, as judged by external physical characteristics. It is said that the social standards of the islanders are still Anglo-Saxon. The Japanese and American Indians both belong to a Mongoloid stock: would Madison Grant consider them a lower type than the Polynesians?

Boas says, "The fourth generation of a people consisting of distinct elements will be almost homogeneous". That certainly will not be true if there is definite segregation combined with random mating, as in this family. If, however, there is assortative mating, which has probably nearly always occurred as a result of racial prejudices, then homogeneity would result, just as is happening in Brazil, where the Métis, the cross between the Spaniard and the Indian chooses a wife who is as unlike an Indian as possible. A similar sexual selection is also taking place in Poland, where the Caucasian-Slavonic cross now chooses the Caucasian rather than the Slavonic type for wife. Again, in Batavia where there is cross breeding, there is selective mating.

The Croatan and Redbones Indians of South Carolina, who are probably descendants of lost native tribes and early settlers, look more like Indians than Whites. The Leunbach family shows that such a result would be expected if there was no selective mating.

Thus in this family, if the Dane, 2, had chosen a purely Danish wife, the Indian types 16 and 18 would not have been born and if the Danish woman, 17, had insisted on a husband of a Danish type, the "Indian" child, 27, would not have been born. Boas, writing of the United States says, "Without doubt, Indian blood flows in the veins of quite a number of our people, but the proportion is so insignificant that it may well be disregarded," but the study of this family suggests that this statement may not be true, for here is seen the possibility that a little Indian blood may have a big effect, for one Indian woman has left her mark upon eleven out of twenty-one descendents, i. e., about 50 per cent, and that mark is as clear in some characteristics in the fifth generation as in the first. So it is possible that the American type may have been influenced by Indian blood much more than has, so far, been recognized.

My very sincere thanks are due to Dr. A. Hyatt Verrill of the Museum of the American Indians, New York City, for photographs and an enlightening letter, to Mr. Louis C. G. Clarke of the Cambridge University Museum of Archaeology and Ethnology, and to Mr. H. A. Braunholtz of the Department of Ethnology, British Museum, for advice and useful suggestions. The paper could not have been prepared if Dr. Leunbach of Copenhagen had not generously put at my disposal a large series of family photographs and given much of his valuable time to answering my questions.

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Bateson's Scientific Papers

TEXTBOOKS of Genetics are not lacking, many of them excellent compendia of pre-digested information—too much to learn readily and yet too little to convey the interest of any particular line of investigation. All too often a devastating dullness is the result, even with the most sincere efforts to be interesting. Lacking adequate illustrations most of our publications on heredity mean nothing at all to the general reader and very little to students, unless they are specialists in the same groups. One does not read understandingly or with any active interest about plants or animals that have never been seen, unless they "appear in person" through the medium of good illustrations. With nothing but abstractions or numbers before them the majority of minds have difficulty in functioning. Hence the well-illustrated literature of genetics serves an essential purpose in education beyond its value as a record for purposes of reference.

The recent publication of the *Scientific Papers of William Bateson** is thus an event of importance in more ways than one. Many of Bateson's contributions were of the greatest scientific value. They were published in many journals and many of them were long out of print, so thy have not been available for ready reference. Bateson wrote widely and clearly and was able to reflect the state of knowledge of a period that saw a most amazing development of our knowledge of heredity. His contributions have a permanent value, not alone because they were treated by one of the great pioneers of genetics, but because they were exceptionally well presented and well illustrated. The literature of genetics already is so extensive that it is, perhaps, not to be expected that all libraries will have the subject exhaustively represented. Nevertheless, all institutions with any pretensions to modern equipment must have working libraries of genetics, of which these two volumes of Bateson's works will be a well-nigh indispensible addition.

With a few changes in chronological order it has been possible to divide Bateson's papers into two series, the earlier dealing mainly with problems of variation and the later with heredity; and on these lines the two volumes are divided. The "break" occurs at about the turn of the century, and it is especially interesting to read the papers toward the end of Volume I in the light of the soon-to-be-made rediscovery of Mendel's Law. (The announcement of this forms the subject of the first paper

*SCIETIFIC PAPERS OF WILLIAM BATESON, Edited by R. C. PUNNETT. Vol. I. Pp. vii+452, 7 plates, Vol. II. Pp. 503, 2 plates. Price 42 shillings each volume. Cambridge University Press, 1928. Macmillan Co., sole American agents.

in Volume II). It has been said that if Mendel's work had not come to light Bateson would have been buried in Westminster Abbey as the discoverer of unit characters and segregation. In this connection several passages make fascinating reading, so close was he to the essential discovery that forty years before had illumined the problem, only to be forgotten for the lack of a Correns, a deVries, a Tchermack or a Bateson to realize its significance. How much the progress of genetic research would have been delayed by a failure to rediscover Mendel's work should be a fertile subject for debate by the followers of the all-important "If", who love to argue the relative importance of the "man" and the "event". That this event had a profound effect on the direction of Bateson's thought can hardly be questioned. His own researches had reached the point where he was in position to apply the new principles with brilliant results. A first-hand acquaintance with this chronicle of the early days of genetics should form part of the cultural background of every student of the subject.

In the two volumes of nearly 1,000 pages are 88 separate papers, 36 plates and numerous text figures. The plates relate largely to plants, but they include mollusces, fishes, beetles (Chrysomelidae) and birds (pheasants). The zoological papers relate to several groups of insects, crustaseans, fishes, batrachians, and mammals, including mice, horses, cats and men. The plants represented in the plates are: Begonia, Bouvardia, Cineraria, Coprosma, Euonymus, Gladiolus, Lethyrus, Linaria, Linum, Pisum, Primula, Spiraea, Streptocarpus, and Veronica. Several other plants have detailed treatment in the text. "Treasure your exceptions" was preached by Bateson, and *practiced* with notable success.

In addition to the contributions to genetic knowledge with which Bateson is to be credited, perhaps no one man (in recent times, at least, and not including taxonomic names) has had the privilege of adding so many words to the English language. Not all the genetic terms coined by Bateson are yet to be found in desk dictionaries, but the number will grow. *Genetics* leads the list, of course; and *allelomorph, homozygous, heterozygous, anisogeny, coupling, repulsion, unit-character* is not a complete enumeration of Bateson's contributions to the vernacular of the science of heredity. It is significant, indeed, that these words are all first used by Bateson, and most of them within a few months of the rediscovery of Mendel's obscure contribution to the *Proceedings of the National History Society of Brunn.*

R. C. C.

Genetics of the Human Constitution

THE first parts of the voluminous work concerning the human constitution edited by Brugsch and Lewy were announced in this JOURNAL two years ago (vol. 18, p. 503). Since then a series of further parts has been issued, some of which should prove to be of unusual interest to geneticists.* The three first issues of the second volume contain contributions by Brugsch, Berliner, Schlossmann and Eckstein, Nogai, Allers, de Crinis, and Josefson. This volume bears the title "General Somatic and Psyche-physic Constitution" and comprises what Brugsch calls the "morphology of the person (individual)". A paper with the latter title by Brugsch himself introduces this volume. Brugsch in it makes an attempt to classify morphologically the different types of human constitutions, and he gives a comparison of the classifications worked out by various authors, illustrating the es-

*BIOLOGIE DER PERSON, edited by TH. BRUGSCH and F. H. LEWY. Parts 5—14. Price 12.—, 16.—, 14.—, 10.—, 15.—, 13.—, 16.—, 14.—, 20.—, and 13.— marks respectively (single issues cannot be purchased).

sential identity of the principal constitutional types among different races. The discussion concerning preferential susceptibility of different constitutional types to various diseases is one of the many problems of genetical interest discussed in this chapter. Brugsch gives a detailed description of the methods of physical anthropology and a summary of the numerical results obtained in the measurement of the different body dimensions and of the indices obtained from them.

M. Berliner in his contribution concerning "retarted types" gives a general discussion of the factors influencing body growth and of the different types of dwarfism. Schlossmann and Eckstein review shortly (and rather superficially) the general characteristics of growth during childhood and the different constitutional types deviating from normal growth. M. Berliner in the following chapter presents the data concerning "adolescence". This paper contains a vast amount of original observations concerning changes in bodily dimensions during growth. The discussion of sex differences in height and weight during growth as well as the report concerning changes in the mortality rate from diphtheria and scarlatina, which at first is higher in males and then becomes higher in females, are especially valuable for geneticists. The changes in mortality rates are a good illustration of the importance of constitutional factors in population studies. Berliner believes that the higher mortality in females from diphtheria and scarlatina in later life is due partly to the weakening effect of menstruation and partly to morphological characteristics of the female thorax. In the following chapter Berliner discusses the "age of involution", the regressive changes in tissues and organs brought about by old age and their differences in different constitutional types. Again, there is a large amount of original observations embodied in this report.

G. Scherr in his contribution "Thanatology and its Importance for the person" gives a description of the different types of death in relation to the individual constitution. S. Nogai presents a valuable compilation concerning "The Physical Constitution of the Japanese" with many interesting comparisons with the results obtained for European populations. R. Allers in the following chapter, entitled "Medical Characterology", outlines the different attempts to define and classify character types. It is only natural that the results of psychoanalysis are treated as the most important source of information in this field. In general, the discussion is very critical, but unfortunately the importance of heredity in an understanding of these problems is entirely neglected. This leads the author to many undoubtedly erroneous conclusions, as for instance the emphatic denial that there are "born criminals".

The third volume is entitled "Organs and Constitution". Of this volume also several issues have been published. The first chapter by de Crinis deals with the "Humoral Constitution". This is a discussion of the relation between the specific characteristics of the body fluids and of the different constitutional types. Particular attention is given to the blood. De Crinis emphasizes the fact that the body fluids bring about the inter-relations between different parts of the body and their functions and thus become the basis for the entity and harmony of the individual. A. Josefson reports on "Personality and Endocrine Glands". This contribution is not very critical and rather incomplete. The following chapter by A. Kronfeld deals with "The Sexual System in its Relation to the Individual and his Constitution" and gives an excellent survey of the problems of sex differentiation and determination with a discussion of the genetic basis of epigenetic factors for the determination of sex and their importance. Particularly valuable appears Kronfeld's digest of our knowledge concerning sexual differences—physical and mental—in man. K. H. Bauer discusses the "Constitu-

tional and Individual Pathology of the Skeleton and Connective Tissue (Stützgewebe)". In the case of osteogenesis imperfecta and other abnormalities—at least for some of which the genetic nature has been demonstrated—Bauer shows that all the different derivatives of connective tissue, cartilage and bone are involved to a greater or lesser degree. This illustrates well the fact that many genetic factors do not determine one particular morphological trait only but influence other, developmentally related, structures as well. The importance of constitutional factors in the structure of teeth is discussed by R. Weber, of the intestines by F. Fleischer, and of the eye by J. Helbren.

The fourth volume which is complete, deals with the sociology of the person. The contributions by C. Coerper and W. Peters contain much information of value for geneticists. Coerper gives a general analysis of the individual fitness for certain trades and professions with regard to the physical conformation. Peters treats the same problems with regard to mental faculties. There are many other contributions in this volume most of which are of sociological interest only. Some of these chapters are distinctly superficial and biased, as for instance the one by R. Michels concerning the "Influence of the Environment upon the Individual".

It may be very difficult in a work of this nature to avoid reiterations of the same problems by different authors; however, there are a number of quite unnecessary repetitions. In certain chapters the presentation could have gained much if the authors had restrained themselves from using obsolete terms (humoral, stigmatisation, and many others). The literature lists of some of the contributons are incomplete and contain many errors.

None of these critical remarks, however, should obscure the fact that Brugsch and Lewy have performed an unusually great service to all interested in the biology of man by bringing together this wealth of information.

Walter Landauer.

Biology for All the Family

Animal Biology, by J. B. S. Haldane and Julian Huxley. Pp. 344, including index and glossary. Price, $2.50. Clarendon Science Series, Oxford University Press, American Branch, N. Y.

When two of the most skillful and popular English writers on biological subjects collaborate in the production of a biology, the prospective purchaser needs no reassurance as to its merits. The book is one of a series dealing with the concept of energy and the authors have been limited somewhat in scope by the necessity of conforming to this general theme.

Although written primarily for children of high-school age, this is no biological bedtime story with a juvenile vocabulary, but rather the attempt has been made to familiarize the reader with biological terminology by means of simple analogies. The result is an easily understandable introduction to biology which should appeal not only to the children to whom it is addressed but to their parents as well.

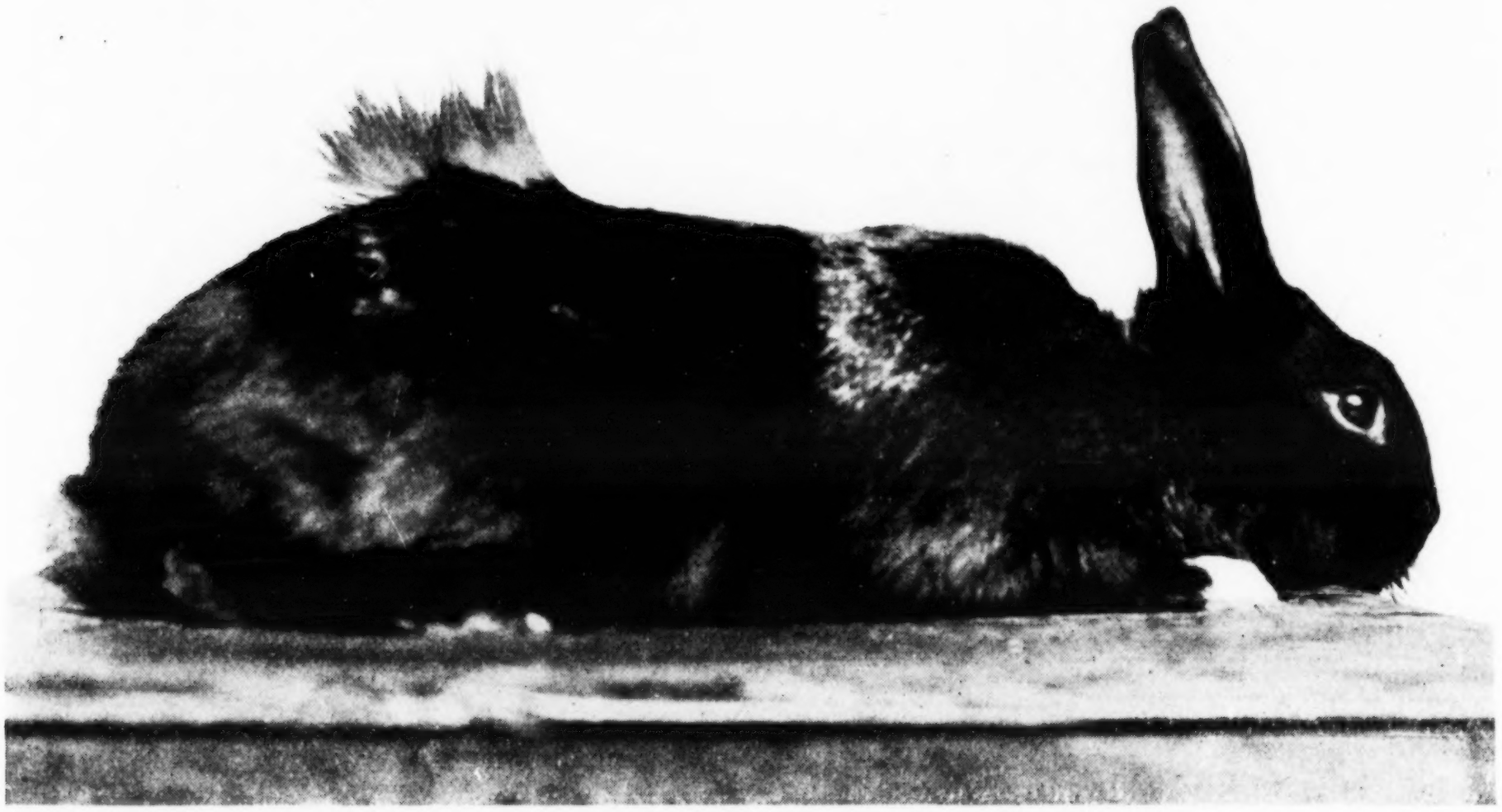
J. H. K.

A BROWN-AND-BLACK RABBIT

A Possible Case of Somatic Segregation

J. N. PICKARD

Animal Breeding Research Department, University of Edinburgh



A "MOSAIC" RABBIT

Figure 15

This rabbit has a coat that is mostly black, and short-haired. It is peculiar, however, in having four patches of brown hair and three of long hair (one of which shows on his back). It is supposed that these patches are due to somatic segregation, and that the rabbit is heterozygous for brown hair-color and for the long-haired Angora type of coat.

A MALE rabbit of peculiar interest has recently been presented to this Department by a well-known Scottish breeder. The rabbit is out of a brown (Havana) doe sired by an unknown buck. It was between eight and ten weeks old when received here on November 19th, 1928, and is of a type and size somewhat similar to the Havana or Dutch.

In colour it is mainly self black, but exhibits traces of Dutch ancestry, having white forefeet and a white nose tip. It is remarkable, however, in that there are four areas of brown-tipped hairs in its coat. These are situated on the right shoulder: a small patch at the right side just where the hind limb joins the body; a large patch on the rump, the greater portion lying on the left side, but also extending to the right, and lastly a smaller area on the left side of the rump and near the previous one. The colours of black and brown are not usually found in the same individual, this being the first case to be recorded in our knowledge.

The brown patches are not the only unusual features exhibited by this rabbit. Whilst it is mainly shortcoated, three patches of longer (Angora) hair are situated on the back towards the hindquarters. These are in close proximity to one another in a com-

paratively narrow strip lying along the vertebra, that nearest the tail covering the largest area. The difference in the length of the hair is considerable, as the short coat measures only 2.8 cms. whilst the Angora patches vary from 5.7 cms. to 6.6 cms. in length. An area, including part of the Angora patch, was shaved and another Angora patch was plucked out on December 12, 1928, and at the time of writing (February 2, 1929) it appears that the differentiation in the hair type is persisting. The rabbit has an exceedingly dense coat of fine texture.

Instances of unusual regional differences in characterisation have frequently been reported in plants and Drosophila, but are distinctly rare in the higher animals. They may be due occasionally to gene mutation, but more commonly are the results of abnormal distribution of whole chromosomes during cellular division, *e. g.*, gynandromorphism. The case now under discussion would seem to belong to the latter class.

The present case is of a rabbit, out of a short-haired Havana doe which must have been homozygous for the recessive brown character and either homozygous or heterozygous for short coat. The sire was almost certainly a black rabbit and probably either homozygous or heterozygous for short coat. The rabbit described in this note, presumably heterozygous for both of the characters black and shorthaired, exhibited patches of the two recessive characters, brown and Angora. This escape of these recessives was probably due to an unusual segregation of the chromosomes, which left the cells in certain areas without the chromosomes carrying the genes for black and for short hair. It is interesting to note that whilst the Angora coat is limited to a somewhat confined area, the brown patches are scattered widely. It would appear, therefore, that the aberrant distribution of chromosomes had occurred twice during development, the chromosome bearing the gene for black being the first to be abnormal in its distribution. Later one chromosome bearing the gene for short hair became involved, but this lead to a lesser ultimate effect, owing to less cellular division than was the case of the colour variation.

The white spotting of the nose and forefeet is not considered remarkable. It is probably due to the presence of one or more of the factors controlling the Dutch pattern, which are frequently found in the Fur Varieties of rabbits.

Summary

The case of a short-coated black rabbit with areas of both brown hair and long coat is described. The possible cause of this abnormal variation through the segregation of the chromosomes is discussed.

A New Journal for Breeders

Under the direction of Dr. Erwin Bauer, a new monthly entitled *Der Züchter,* a journal for theoretical and applied genetics, made its first appearance in April, 1929. It is devoted mainly to plant-breeding. The publisher is Julius Springer, Berlin W 9, Linkstr. 23/24, Germany, and all communications to the editor are to be sent to that address. The price of the publication is $7.50 per year.

TWIN AND TRIPLET BIRTH RATIOS

A Further Study of the Interrelations of the Frequencies of Plural Births

R. L. JENKINS*

THE final evaluation of the data concerning human inheritance, gained from the study of twins, is probably impossible without more adequate knowledge of the nature of twinning. This problem must be attacked from many angles, and one that should not be overlooked is the relation of twinning to the higher plural births.

In a previous paper[1] it was pointed out, that among a population of mothers of any given age group, the frequency of triplet births may be predicted as the square of the frequency of twin births, and that the total triplet births in a given population of all ages of women may be predicted by the formula $T = \Sigma P^2 n$, where T is total triplet births, Σ represents the summation of the following expression, P a variable, the frequency of twin births, a function of the age of mother, and n, another variable, the number of births by mothers of the given age. It was further shown that, assuming that the same probability factors govern all the multiple pregnancies, and that the probabilities of the development of dizygotic twins and of monozygotic twins are separate factors independent of each other, this relationship can be logically expected. If an extra egg is fertilized with a frequency a, and the same probability factor operates in the fertilization of more than one extra egg, then two extra eggs might be expected to be fertilized with a frequency of a^2. Thus the frequency of trizygotic triplets should be a^2. The rest of the reasoning is indicated in the following diagram:

		Frequency	*Total frequency*
○ ○	Dizygotic twins	a	a + b
⊖	Monozygotic twins	b	
○ ○ ○	Trizygotic triplets	a^2	$(a + b)^2$
⊖ ○	Dizygotic triplets	2ab	
⊛	Monozygotic triplets	b^2	
○ ○ ○ ○	Quadrazygotic quadruplets	a^3	$(a + b)^3$
⊖ ○ ○	Trizygotic quadruplets	$3a^2b$	
⊖ ⊖	Dizygotic† quadruplets	$1\frac{1}{2}ab^2$	
⊛ ○	Dizygotic† quadruplets	$1\frac{1}{2}ab^2$	
⊕	Monozygotic quadruplets	b^3	

*Studies from the Institute for Juvenile Research, Chicago, Herman M. Adler, Director. Series B, No. 147. The writer wishes to express his indebtedness in this work to the suggestions of Professors H. H. Newman, L. L. Thurston, I. S. Falk, and A. J. Carlson, and to Dr. Roy Keggereis.

†In the preceding paper, this was written:

		Frequency
⊖ ⊖	Dizygotic twins	$2ab^2$
⊛ ○		ab^2

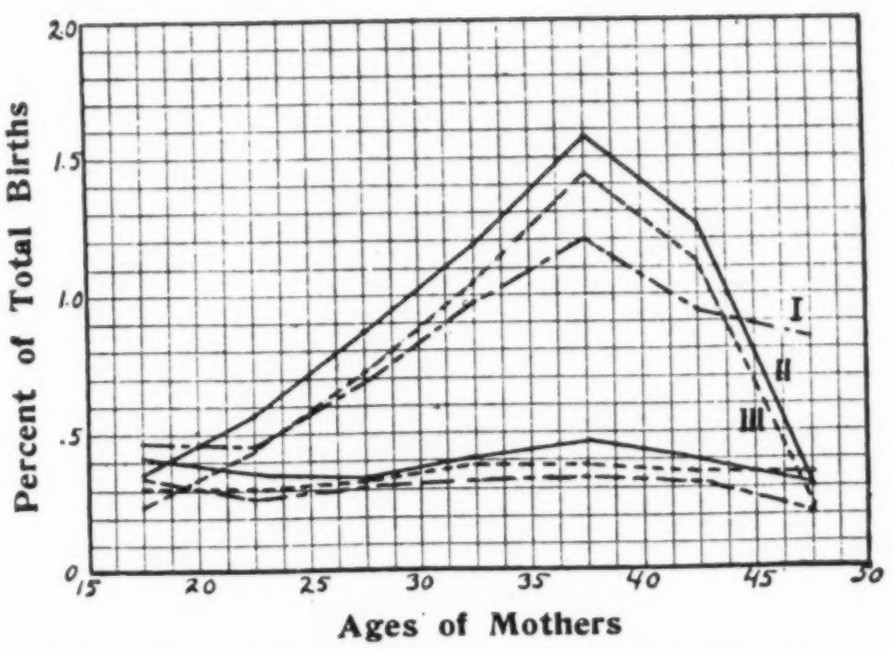
Further study has convinced the writer that the first formula given here is the more logical one.

It will be seen that the relation that the frequency of quadruple births will be the cube of the frequency of twin births can also be expected from this reasoning.

Attention was called to the paradoxical finding that while these formulas give reasonable agreement with empirical facts in regard to the total number of triplet births, they do not predict within the limits of chance error the frequencies of different types of triplets — monozygotic, dizygotic, and trizygotic. We find ourselves in the anomalous position of having set up supports and built a roof on them, only to see the supports crumble and the roof remain firmly in mid-air. Even the slightly inquisitive observer will be moved to investigate further such an interesting phenomenon, and perchance to look for other supports to the roof, previously unrecognized. It is the purpose of this paper to present a hypothesis which appeals to the writer as a possible explanation of this discrepancy.

The conclusion that the foregoing method is false as a means of predicting the frequency of each type of triplets is reached from a study of the sexes of triplets in the light of an extension of Weinberg's differential method suggested by Dahlberg. Dahlberg pointed out that if we assume that the sex of triplets from separate eggs is determined each independently of the other, then if we have trizygotic triplets, the chances will be 1 in 4 (disregarding the slight excess a male births) of trizygotic triplets being all of the same sex. Of the dizygotic triplets, half the groups should be all of the same sex, and of the monozygotic triplets, of course all will be same-sexed.

Figure 16 and Table V show the variation in frequency of monozygotic and dizygotic twin births for various ages of mothers. The statistics for France, 1907-1910, have been selected for this demonstration as being the most nearly typical. By summation of



THE FREQUENCIES OF MONOZYGOTIC AND DIZYGOTIC TWIN BIRTHS BY AGES OF MOTHERS

Figure 16

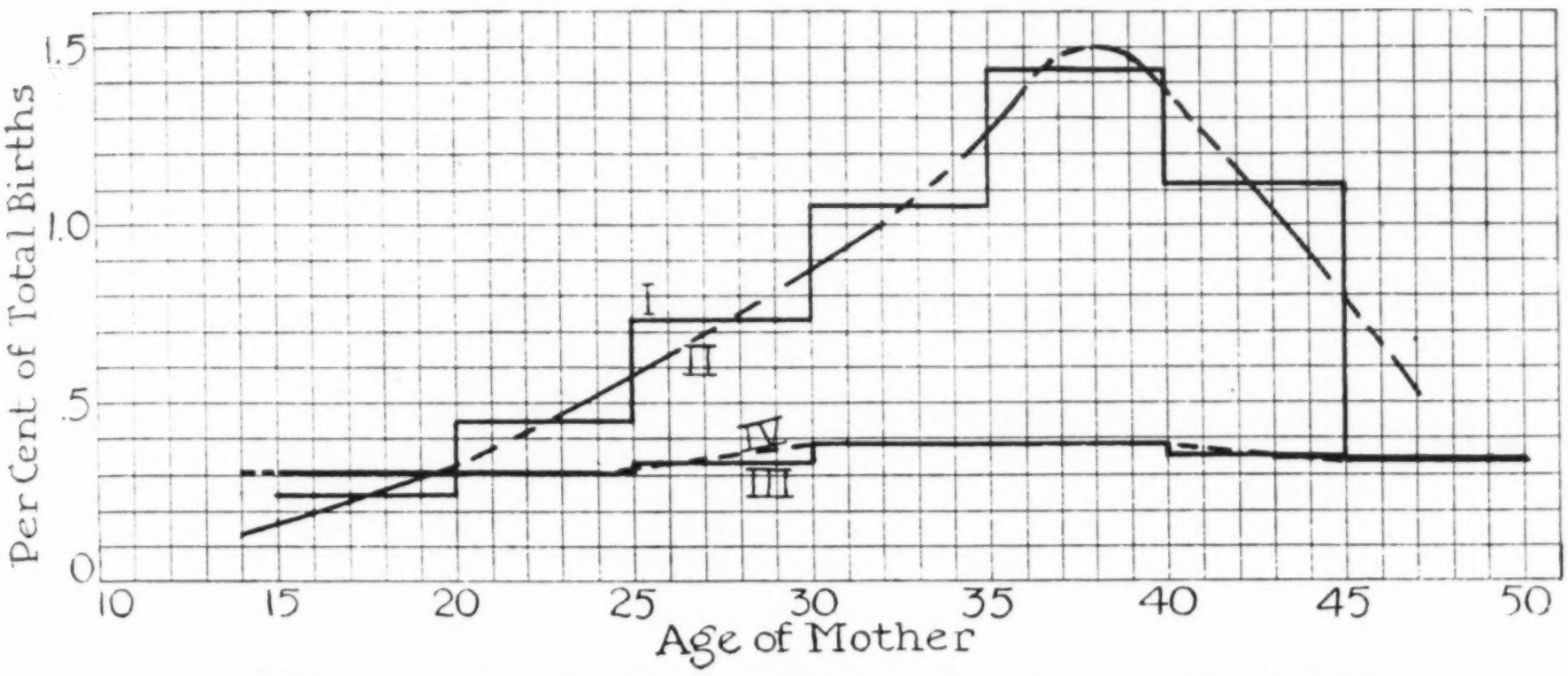
I. Dizygotic Twin Births, France 1902-1906. II. Dizygotic Twin Births, Finland 1878-1916. III. Dizygotic Twin Births, France 1907-1910. The corresponding lower graphs represent the frequencies of monozygotic twin births.

the simultaneous products a^2n, $2abn$, and b^2n, the expected number of triplets of each type in this population was found to be 239 trizygotic, 180 dizygotic, and 38 monozygotic (239.1, 179.7, and 37.8 being the exact values). If now we take one-fourth of the calculated number of trizygotic, one-half of the dizygotic and all of the monozygotic sets to be same-sexed, we obtain 187 same-sexed and 269 opposite-sexed triplet sets. The same sexed triplet sets bear to the opposite sexed triplet sets the ratio of 0.695. For the sake of simplicity this relation will hereafter be referred to as the triplet sex homogeniety index.

Calculations for France (1902-1906)[4] and for Denmark (1896-1910)[4] give a triplet sex homogeniety ratio of 0.691 and 0.676 respectively.

On the other hand the observed index in the data from Prussia (1826-96)[2] is 0.876, while that from the statistics of Nichols[3] is 0.933. This is a striking discrepancy from the predicted ratio.

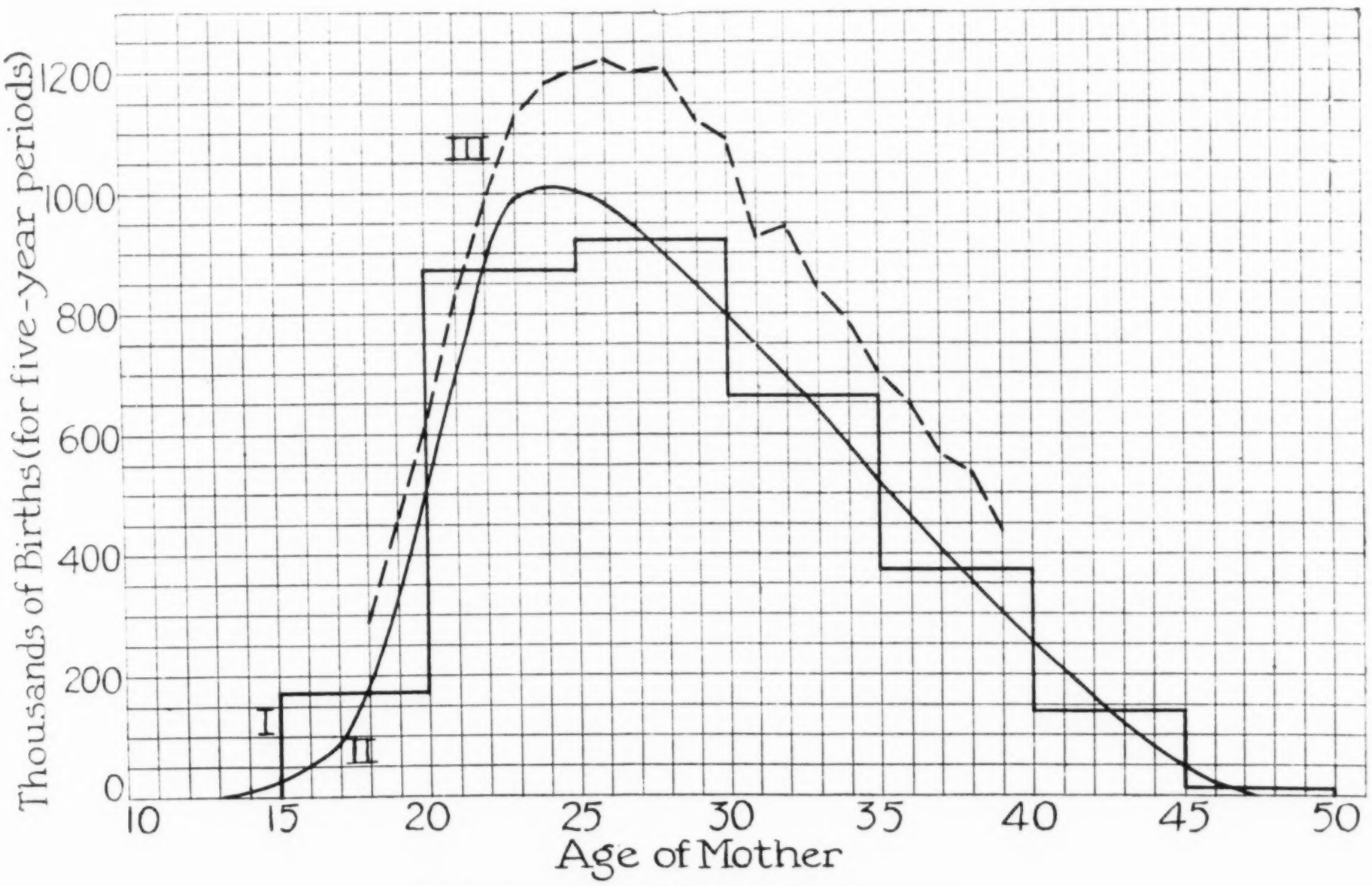
One source of error in the predicted index is the handling of the birth rate and twin frequency for each five-year period as a constant, when, of course,



FREQUENCIES OF TWIN BIRTHS BY AGE OF MOTHERS

Figure 17

I—Histogram of frequencies of dizygotic twin births. II—Frequency curve drawn from I. III—Histogram of frequencies of monozygotic twin births. IV—Frequency curve drawn from III.



BIRTHS BY AGE OF MOTHERS

Figure 18

I—Histogram of births by ages of mothers. II—Frequency curve drawn from I. III—Frequency polygon for Australia, 1908-23.

in fact each of these varies through the five years. The author sought to test the importance of this by constructing continuous frequency curves from the five-year period data, and calculating the result by yearly intervals. Because of the error which would be introduced if the standard formulas were used to construct a frequency curve on so few intervals, the curves (Figures 17 and 18) were constructed "by hand."

Table VI gives the numerical data obtained.

The calculation by yearly intervals also gives a triplet sex homogeniety index of 0.695. This evidently cannot account for the discrepancy.

Additional observed data, practically all of the same character, are tabulated in Table VII.

It will be observed that the discrepancy between the observed and calculated ratios is too great to admit of any explanation save that the proposed relation is incorrect. The predicted triplet sex homogeniety index is too small, and this means that the proportion of monozygothic triplets predicted is too small or the proportion of trizygotic triplets too large, or both.

There is one other source of material against which to check the predicted frequencies. This is the comparison of the number of each type of triplet among the cases which have been classified as one, two or three egg triplets.

Table I gives the data which have been available to the writer.

Table I

	Trizygotic	Dizygotic	Monozygotic
Saniter	9	14	2
Strassman	4	5	1
Hust	1	—	1
Wilder	—	—	1
Newman.....	—	1	—
	—	—	—
	14	20	5
	36%	51%	13%
Predicted*.....	52.3%	39.4%	8.3%

These figures would give us a triplet sex homogeniety index of 0.902. This is in good agreement with the observed index, while again the observed and predicted distributions do not agree. Of course the number of cases is too small to base much upon.

We can also extend Weinberg's differential method to cover quadruplets. Disregarding the excess of male births, the diagram below† indicates the expected distribution of each type of quadruplets.

The expected percentages of each type can now easily be calculated from the data for France, 1907-1910, and are found to be: 25.3% all of same sex; 45.2% three of same sex; 29.5% two of each sex. The observed frequencies in 185 cases collected from the literature by the author is 72 or 38.9% all of the same sex, 64 or 34.6% three of same sex, 49 or 26.5% two of each sex. (Table VII.)

One can not draw any definite conclusion because of the large chance error involved in dealing with so small a number of cases, but the agreement does not appear to be at all good.

The hypothesis here presented is an addition to the working hypothesis presented by Dahlberg in 1926.[4] Dahlberg suggests that twinning is the result of an innate tendency of either sex cell to double formation. In the case of the egg, this double formation may occur before the reduction division and fertilization, in which case two eggs arise, causing the production of dizygotic twins, or the tendency may express itself after the reduction division and fertilization, in which case monozygotic twins result. If the tendency to double formation be borne by the sperm, it can cause only monozygotic twin formation.

If the tendency to double formation

*From data for France, 1907-1910.

†*Type of Quadruplets*	*All same sex*	*Fraction of each group* 3 *of* 1 *sex*, 1 *of other*	2 *of each sex*
○ ○ ○ ○	1/8	1/2	3/8
⊖ ○ ○	1/4	1/2	1/4
⊖ ⊖	1/2	None	1/2
☮ ○	1/2	1/2	None
⊕	All	None	None

be expressed late in development, double monsters result.

Another manner of production of dizygotic twins has been proven—the liberation of two eggs from separate ovarian follicles. These twins would necessarily be dizygotic.

We have then, theoretically, two methods of formation of dizygotic twins—the liberation of two eggs from two separate follicles, and the fission of a single egg before fertilization. The symbol a represents the sum of the frequencies of these occurrences. Likewise, there are supposedly two causes of monozygotic twin formation, double formation by the zygote from a character inherent in the egg, and double formation from a character of the sperm cell. The sum of the frequencies of the occurrences is represented

By hypothesis the third causes are fundamentally related—there is no inherent tendency of the eggs to double formation which may express itself either before or after fertilization. Let us remember then, that the frequency, a, is the sum of two frequencies—the frequency of fission of the egg before the reduction division and the frequency of the rupture of two ovarian follicles in the same ovulation. Likewise, the frequency b is the sum of the frequency of double formation in the zygote caused by a character of the egg, and of that caused by a character of the sperm. The total frequency of twinning is $(a + b)$. As indicated above, we should expect, *a priore*, that the probability of two tendencies to double formation ocurring in the same pregnancy would be $(a + b) \times (a + b)$. This would give us a frequency of a^2 for trizygotic triplets, $2ab$ for dizygotic triplets, and b^2 for monozygotic triplets.

However, if the first twin-forming tendency of the egg be expressed before the reduction division and fertilization, it must express itself as a simple fission of the egg that must necessarily occupy some time, and that if the reduction division have a somewhat fixed place in time, then unless we assume that two twin-forming divisions can express themselves simultaneously in a single cell, this should diminish the likelihood of the second twin-forming tendency expressing itself before reduction and fertilization; and if we assume that this tendency is found to be expressed, should thereby increase the likelihood of the expression occurring after fertilization. This would decrease the number of trizygotic triplets and increase the frequency of monozygotic sets. If we represent this diminution in the probability of the second twin-forming tendency expressing itself before the reduction division and fertilization as c, we arrive at the conclusion that the occurrence of triplet births should be predicted by the equation $(a + b) \times [(a - c) + (b + c)]$.

It is obvious that the total product of $(a + b) \times [(a + c) + (b - c)]$

TABLE II—Sex Distribution of Quadruplet Sets

	4♂	3♂	2♂	1♂	4♀
Nichols[4]	5	2	7	11	11
Brattstiom[5]	2	3	6	1	7
Hafeli[6]	2	1	2	2	3
Pinther[7]	5	8	9	7	6
Conrad[8]	5	4	....	2	2
U. S. Birth Registration Area[9]	5	2	5	4	3
Collected by author[10]	8	9	20	8	8
	32	29	49	35	40

All four of same sex ... 72 cases, 38.9%
Three of one sex, one of opposite sex ... 64 cases, 34.6%
Two of each sex ... 49 cases, 26.5%

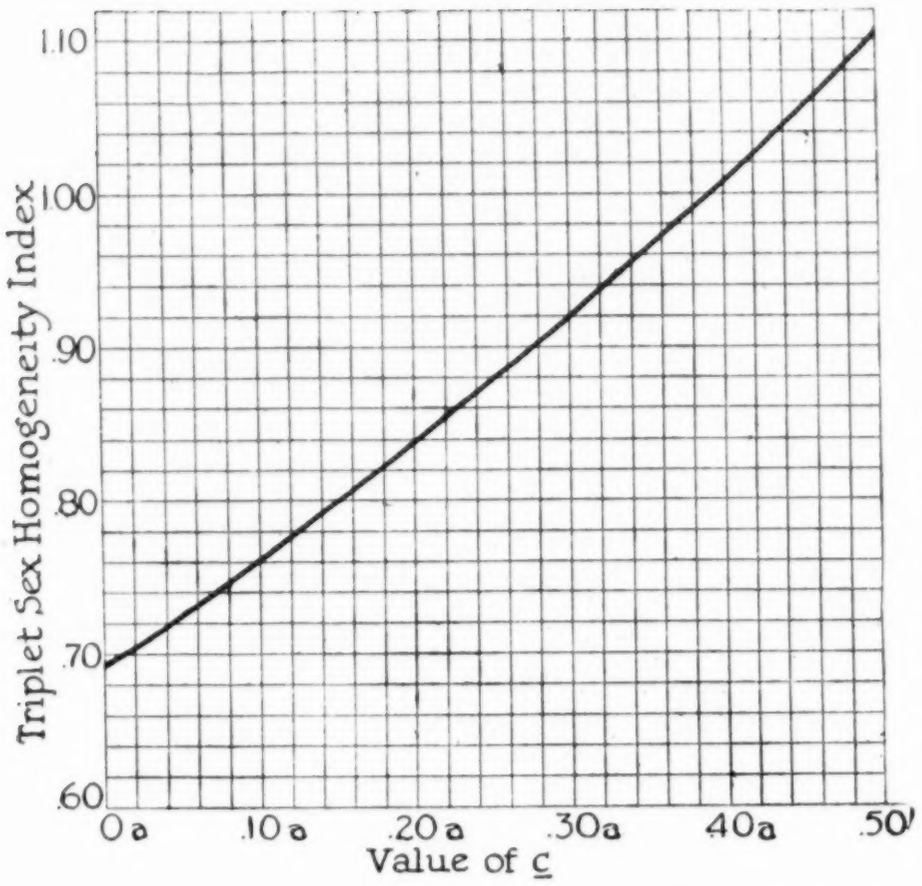


Figure 19

Relation of the triplet sex homogeniety index to *c*, as predicted from the data for France, 1907-1910.

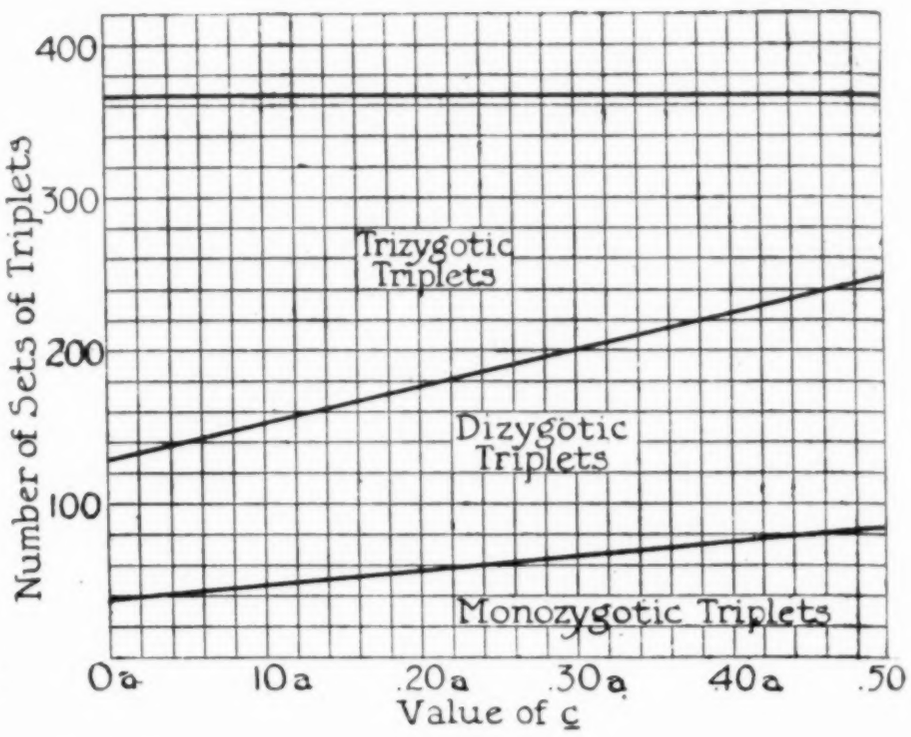


Figure 20

VALUES OF *C*

The predicted numbers of one-egg, two-egg, and three-egg triplets for France, 1907-1910, for various values of *c*, a factor expressing the chance that fission of the egg occurred before fertilization.

is equal to $(a + b)^2$ though the partial products will be different.

The diagram below* indicates the relationships.

The total number of trizygotic triplet sets in a given series of births would be $\Sigma\ (a^2n - acn)$, the total number of dizygotic triplet sets $\Sigma\ (2abn + acn - bcn)$ and the total number of monozygotic $\Sigma\ (b^2n + bcn)$.

If, now, we assume that the relationship of *c* to *a* is constant for all ages of mothers, then by the extension of Weinberg's differential method alluded to before, we may write the equation below.† Substituting varying values for *c* we obtain Table IV.

The relationship is graphically shown in Figure 19 and Figure 20. The curve in Figure 19 is a section of an hyperbola.‡

It will be seen that the predicted frequencies of each type of triplets, and the predicted triplet sex homogeniety index are in good agreement with the observed findings when $c =$ about .30 *a*.

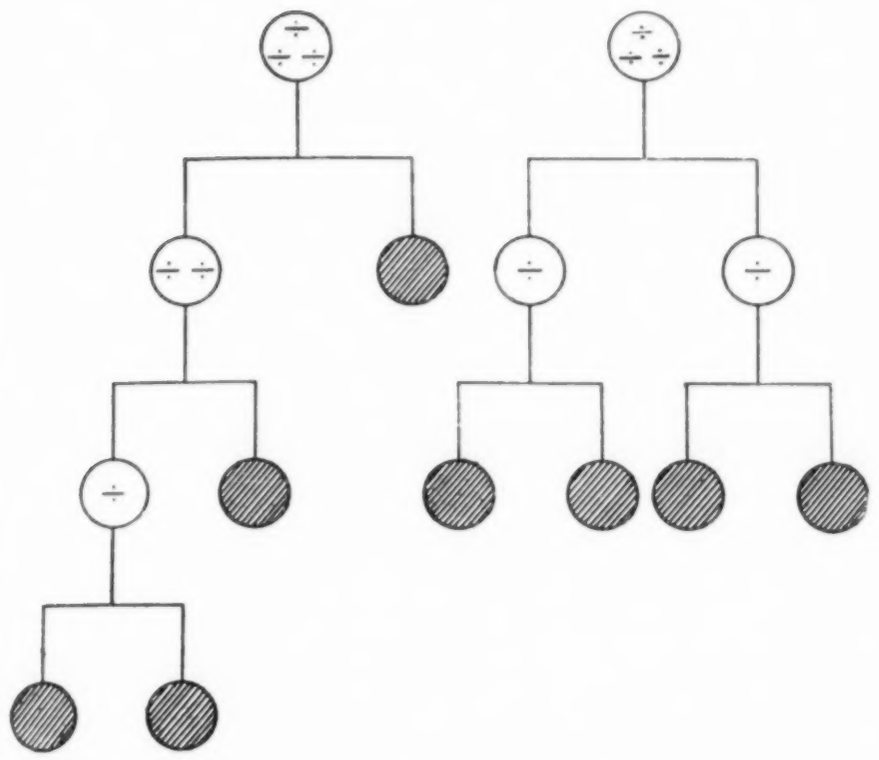
Quadrazygotic quadruplets might be be formed by repeated fission of a

---

			Derivation	*Frequency*	
*	○ ○	Dizygotic twins	a	a)	$(a + b)$
	⊖	Monozygotic twins	b	b)	
	○ ○ ○	Trizygotic triplets	a (a — c)	$a^2 - ac$	$(a + b)^2$
	⊖ ○	Dizygotic triplets	a(b + c) + b(a—c)	$2ab + ac - bc$	
	⊛	Trizygotic triplets	b (b + c)	$b^2 + bc$	

†$\dfrac{\Sigma\ (a^2n - acn)\ \frac{1}{4} + \frac{1}{2}\ \Sigma(2abn + acn - bcn) + \Sigma\ (b^2n + bcn)}{\Sigma\ (a^2n - acn)\ \frac{3}{4} + \frac{1}{2}\ \Sigma(2abn + acn - bcn)} = \dfrac{\text{Same sexed triplets}}{\text{Opposite sexed triplets}}$

‡It will be seen that this equation of the type $\dfrac{K + K_1X}{K_2 + K_3X} = Y$ which reduces to the form $K_3XY - K_1X + K_2Y = K$. This will be recognized easily as the equation of an hyperbola.



TWO TYPES OF QUADRUPLETS

Figure 21

Showing how quadrazygotic quadruplets might be formed by two types of repeated fission of a single ovum previous to maturation.

single ovum previous to maturation, in either of two manners, as is illustrated by Figure 21.

Let us assume that these two types of successive fission occur with equal frequency in the production of quadrazygotic quadruplets. Then by our hypothesis the first type of quadrazygotic quadruplet formation should occur with a frequency of $\frac{1}{2}a(a—c)(a—c)$. With the second type of quadrazygotic quadruplet formation, the third factor would be different and smaller—possibly $(a—2c)$. In this case the last two divisions must be successive while in the other they might be simultaneous. The total frequency of quadrazygotic quadruplets, then should be $\frac{1}{2}a\ (a—c)\ (a—c) + \frac{1}{2}a\ (a—c)\ (a—2c)$ or $a\ (a—c)\ (a—1\frac{1}{2}c)$. By a similar process of reasoning the diagram below* can be developed.

If we apply this formula to the data for France 1907-1910, we obtain Table III:

TABLE III

C in % of a	*All of samesex*	*Three of same sex*	*Two of each sex*
0	25.3%	45.2%	29.5%
25	35.3%	39.0%	25.7%
28	36.6%	38.2%	25.3%
30	37.4%	37.6%	25.0%
33	38.8%	36.6%	24.6%
50	46.8%	31.0%	22.2%
Reported cases	38.9%	34.6%	26.5%

Type ○○○○	*Quadruplets Derivation*		*Frequency*
*(Quadrazygotic Quadruplets)	$a(a—c)(a—1\frac{1}{2}c)$	=	$a^2—2\frac{1}{2}a^2c+1\frac{1}{2}ac^2$
⊖○○	$a(a—c)\ (b+1\frac{1}{2}c)+$		
(Trizygotic Quadruplets)	$a(b+c)(a—1\frac{1}{2}c)+$		$3a^2b+2\frac{1}{2}a^2c—5abc—3ac^2+$
	$b(a—c)\ (a—1\frac{1}{2}c)$	=	$1\frac{1}{2}bc^2$
⊖⊖	$a(b\ \ c)(b+1\frac{1}{2}c)+$		$\{1\frac{1}{2}ab^2\ 2\frac{1}{2}abc—1\frac{1}{4}b^2c+$
⊛○	$b(a—c)(b+1\frac{1}{2}c)+$		$\{\frac{3}{4}ac^2—1\frac{1}{2}bc^2$
(Dizygotic Quadruplets)	$b(b+c)\ (a—1\frac{3}{4}c)$		$\{1\frac{1}{2}ab^2+2\frac{1}{2}abc—1\frac{1}{4}b^2c+$
			$\{\frac{3}{4}ac^2 1\frac{1}{2}bc^2$
⊕	$b(b+c)(b+1\frac{1}{2}c)$	=	$b^3+2\frac{1}{2}b^2c+1\frac{1}{2}bc^2$

TABLE IV—Data from Statistics for France, 1907-1910, Calculated by Five-Year Periods

C in % of a	*Trizygotic Triplets* No.	%	*Dizygotic Triplets* No.	%	*Monozygotic Triplets* No.	%	*Triplet Sex Homogeniety Index*
0	241	52.4	181	39.3	38	8.3	0.695
15	205	44.6	203	44.2	51	11.2	0.800
20	193	41.9	211	45.9	56	12.2	0.838
25	181	39.3	219	47.5	61	13.2	0.878
28	174	37.7	223	48.5	63	13.8	0.903
30	169	36.7	226	49.2	65	14.1	0.919
33	162	35.1	231	50.1	68	14.8	0.945
35	157	34.1	234	50.8	70	15.1	0.962
50	121	26.2	256	55.7	83	18.1	1.105
Reported cases	14	35.9%	20	51.3%	5	12.8%	0.902

It will be observed that the calculation with $c = 0.30$ gives a reasonable agreement for so small a number of cases—a distinctly better one than the method of (a + b).[3] This formula, then, is adequate to account for the statistical findings, as far as they go.

The writer is entirely aware that the assumptions upon which this formula is built are totally hypothetical. This statistical reasoning is presented merely as an effort to explain an observed paradox and in the hope that it may prove of use in gaining a more thorough understanding of the processes of twinning.

Summary

It was shown in a previous article that the total number of triplet births in a given population may be predicted by the formula $T = \Sigma P^2 n$, in which T represents the total triplet births in a population; P a variable, frequency of twin births, a function of the age of mother; and n another variable, the number of births by mothers of that age.

If one represents the frequencies of monozygotic and dizygotic twin births by a and b respectively, and assumes them unrelated, this formula can be logically derived in the following form, $T = \Sigma (a^2+2ab+b^2)n$ or $T = \Sigma (a+b)^2 n$, inasmuch as trizygotic triplets might be expected to occur with a frequency a^2, dizygotic with a frequency $2ab$, and monozygotic with a frequency b^2.

Notwithstanding the fact that the formula is logically derived in this manner, the observed triplet sex homogeniety index (ratio of same-sexed triplet sets to opposite-sexed triplet sets) is not in agreement with the triplet sex homogeniety index predicted from these expected frequencies.

By a modification of the hypothesis of twinning presented by Dahlberg in 1926, it is possible to account for this discrepancy. This hypothesis holds that there are three causes of twinning:

1. Release of two eggs from two separate ovarian follicles. This always causes dizygotic twinning.
2. Tendency of the egg to double formation. If this be expressed before the reduction division and fertilization, dizygotic twins result. If it be expressed subsequently, the twins are monozygotic.
3. Tendency of the sperm to double formation. This results in monozygotic twinning.

The hypothesis here presented is that if, under the above assumptions, triplet formation occurs as a result of two tendencies of the egg to double formation, then since the expression of the first doubling tendency must necessarily require some time, it would seem reasonable that the second doubling tendency to be expressed would have an increased likelihood of being delayed until after the reduction division and fertilization.

TABLE V—Frequency of Twin Births by Ages of Mothers. (From statistics for France, 1907-1910. Data taken from Dahlberg[4])

Age of mother	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Frequency of dizygotic twins (percent of total births)	.248	.453	.734	1.064	1.438	1.117	.340
Frequency of monozygotic twins (percent of total births)	.310	.312	.338	.379	.385	.360	.355
Total births in thousands	175	868	925	658	386	144	14

The number of triplet births would then be predicted for the formula—

$$T = \Sigma (a + b) [(a - c) + (a + c)] n$$

where c represents this diminution in the likelihood of the second doubling tendency expressing itself before fertilization because of the time occupied in the first double-forming fission of the egg. The frequency of trizygotic triplets would be a^2—ac, of dizygotic triplets $2ab + ac - bc$, and of monozygotic $b^2 + bc$.

The number of quadruplets (Q) born in a given population might be predicted by the formula—

$$Q = \Sigma (a + b) [(a - c) + (b - c)] [(a - 1\frac{1}{2}c) + (b + 1\frac{1}{2}c)] n$$

in which $a (a - c) (a - 1\frac{1}{2}c)$ equals the frequency of quadrazygotic quadruplets, and so on.

The percentages of each type of triplets, the sex grouping for both triplets and quadruplets, as predicted by this hypothesis, when c has a value of about .30a, *agree reasonably well with the observed data.*

TABLE VI—Frequency of Twin Births by Ages of Mothers. Data by Year Intervals

From frequency curve (figures 2 and 3) constructed from histograms													
Age of mother	14	15	16	17	18	19	20	21	22	23	24	25	26
Frequency of dizygotic twins %	.14	.17	.20	.23	.26	.30	.34	.38	.42	.47	.53	.58	.64
Frequency of monozygotic twins %	.31	.31	.31	.31	.31	.31	.31	.31	.31	.31	.31	.32	.33
Total births in thousands	2	6	10	16	34	68	100	136	180	198	202	202	198

(continued)										
Age of mother	27	28	29	30	31	32	33	34	35	36
Frequency of dizygotic twins %	.70	.76	.82	.88	.94	1.01	1.09	1.11	1.27	1.38
Frequency of monozygotic twins %	.34	.35	.36	.37	.38	.38	.38	.38	.38	.38
Total births in thousands	190	180	170	160	148	138	126	116	104	94

(concluded)											
Age of mother	37	38	39	40	41	42	43	44	45	46	47
Frequency of dizygotic twins %	1.47	1.50	1.47	1.39	1.27	1.17	1.06	.93	.80	.66	.43
Frequency of monozygotic twins %	.38	.38	.38	.38	.37	.36	.35	.35	.35	.35	.35
Total births in thousands	82	72	62	52	44	34	24	14	8	4	2

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TABLE VII—Data on Triplet Sex-Distribution from Various Sources

	Same-sexed Triplet sets	Opposite-sexed triplet sets	Triplet sex homogeniety index
France 1907-1910 (predicted)	187.4	269.2	,695
" 1902-1906 (predicted)	205.9	297.8	.691
Denmark 1896-1910(predicted)	92.3	136.6	.676
France 1907-1910 (predicted by one year intervals)	189.4	272.5	.695
Prussia 1826-96	3,612	4,121	.876
Data from Nichols: 1893-94) Michigan1898-1900)	10	15	
England & Wales 1845, 1846, 1852	49	37	
Italy 1872-1880	690	713	.968
1871-1889) Austria1896-1901)	1,023	1,039	.985
Hungary 1876-1880	244	348	.701
German Empire 1872-1880) 1901-1902)	1,059	1,147	.923
Belgium 1841-1885) 1890, 1895, 1900)	413	.431	.958
Sweden 1871-1880	93	112	.830
Total	3,583	3,840	.933